Constructing a Green Future

Sustainable and Energy Efficient Tribal Building Workshop

June 8, 2007

Flagstaff, Arizona

Produced by the

Institute for Tribal Environmental Professionals

in cooperation with the Grand Canyon Trust and the State of Arizona

SUSTAINABLE BUILDING and ENERGY for ARIZONA TRIBES

TOOL KIT

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SUSTAINABLE BUILDING and ENERGY for ARIZONA TRIBES

This tool kit has been developed by the Institute for Tribal Environmental Professionals (ITEP) to provide basic information about sustainable energy and building practices, considerations, and planning to guide projects of Arizona Tribes. It is intended to:

1. Give tribal project decision makers and planners and overview of sustainable and "green" building and energy development practices and options to benefit their people.

2. Serve as a tool to support those decision makers and planners in evaluating and choosing sustainable options as they develop projects with architects, contractors, suppliers, or other building professionals.

What follows is an extensive listing of sustainable practices.

- Don't be overwhelmed by this, or think you must use all of it; it is presented as a checklist of considerations.

- What is important is gaining an awareness of concepts and terminology, so you can include all items you can when making decisions with building team members and contractors.

- This vocabulary and knowledge is essential in communication with others, as planning and building is very complex, involving communications with many professionals and publics.

GUIDING PRINCIPLES of SUSTAINABLE DEVELOPMENT

- **Meet people's economic and social needs far into the future.**
- **Preserve the integrity of ecological processes and historical and culturally diverse values.**
- **Gradually reduce reliance on non-renewable natural resources, such as gas, oil, coal, nuclear.**
- **Gradually increase reliance on renewable sources of energy such as wind and solar.**
- **Reduce reliance on and limit release of toxic substances that do not break down in nature**
- **Use land in ways that meet diverse needs, conserve financial and natural resources, and preserve its ability to meet future needs.**

Sustainable Development is not just about creating something new out of nothing - it's about learning from and building on the wisdom of the past. It is based on the principles of self-reliance, fulfillment of basic needs, and an emphasis on quality of life. Sustainable Development is about connecting the wisdom of the past to the direction of the future. It weaves together and balances considerations of economics, environment and culture. It always utilizes a long-term perspective.

STATEMENT OF NEED

Housing, along with business and community support buildings, is the most important issue facing Arizona tribes today. Most existing buildings were constructed several decades ago, and in many cases, because of substandard materials, poor or non-existent construction management, and blatant disregard for traditional ways of living, these homes and buildings do not meet the minimal needs of the people. Arizona has some of the harshest climates in North America. The majority of existing homes and buildings were not designed to meet the environmental stresses found on most reservations, and many are in need of replacement. Many homes do not have central heating, use inefficient wood stove, and many can't maintain comfortable temperatures in winter. Many homes in desert areas can't maintain comfortable temperatures during summer months.

Attempts to rectify these situations through HUD, BIA and tribal housing authorities have provided some relief. However, bureaucratic red tape, redundancy in services, and adherence to antiquated subdivision planning concepts and housing designs that most often ignore traditional cultural values and more efficient planning practices, have led to an apathy about housing. Lost is the sense of pride and "homemanship" of a dwelling and work place where reverence to the land and home and family is everything. Common sense energy issues, addressed with simple non-mechanical devices, like summer shade structures or solid walls to keep in cool in the summer and keep out cold in winter, make traditional structures energy conscious in their own right. Modern planning and design have ignored completely these fundamental principles. America faces a deepening energy crisis, with deepening dependence on foreign fuel, and fossil fuel use increases global warming. There is a need to build homes and buildings that have spirit, maintain connections to the past and tradition, restore pride of ownership and meet the energy and social challenges of a changing future. The sustainable or "green" concepts provided in this tool kit provide solutions to these challenges.

The United States as well as the nations of the world we import oil and gas from have passed their peak energy production (over half their oil and gas reserves have been extracted) while energy demand in the US and other countries keeps increasing. This means prices will continue to rise, and energy shortages will happen in the future. Arizona is a desert state and water supplies are in short supply, requiring conservation measures to make current sources last longer and more energy to develop transport more remote sources.

Buildings account for about 36% of the nation's total energy use, 65% of electricity consumption, and 30% of raw materials use, 12% of potable water consumption, 35% of carbon dioxide emissions, and 49% of sulfur dioxide emissions. In contrast, sustainable buildings may use 40% less energy, 30% less water, and eliminate the use of potentially harmful chemicals. These practices may reduce construction waste by up to 90% and may reduce the up-front costs for building projects.

INTRODUCTION to SUSTAINABLE BUILDING and ENERGY

Everyone is affected daily by the buildings they live and work in, the community infrastructure that supports them, and the cost of energy to keep the whole system going.

This tool kit will focus primarily on building practices. Sustainable building has a major impact on energy use and conservation, thus energy will be primarily addressed in terms of increased energy efficiency (and reduced energy dependency) through wise use and conservation in building practices. Local energy generation will be discussed in Part 3 as a sustainability strategy for promotion of energy independence.

► *What is green/ sustainable building?*

"Sustainability, in its broadest scope, refers to the ability of a society, ecosystem, or any such ongoing system to continue functioning into the future, without being forced into decline through exhaustion or overloading of the key resources on which that system depends (American Institute of Architecture)."

"Green building" or "sustainable building" is the practice of creating healthier and more resource-efficient models of construction, renovation, operation, maintenance, and demolition. Elements include: Energy efficiency; Water efficiency; Materials efficiency and healthiness; and Indoor Air Quality. It is all ultimately about resource efficiency and high performance. Sustainable building emphasizes high performance while enhancing the beauty and function of a space. Sustainable design involves a systematic effort to create a useful space that takes maximum advantage of the local climatic and geographic benefits while compensating for its less beneficial aspects. You may also hear sustainable building referred to as Smart building and Intelligent building because it is logically the best way to go when all aspects are considered.

Though many people view green building as "alternative building" design using adobe, straw bale or other unusual base construction materials, this is not the essence of green building. In fact, most green (high performance) buildings being built today will use stud framing, and not look much different than other homes in the neighborhood or town. As tribes, communities, and individuals get involved it choosing architectural designs that are more culturally sensitive to their natural environment and to their culture, then many kinds of base construction materials are available to build the green high-performance buildings referred to in this Tool Kit.

Key elements of Sustainable Development are:

- **Grassroots Involvement:**

Buildings of choice by informed users include aesthetics, healthy indoor environment, and durability for low maintenance. Planning and decision making is a community driven process, not a developer driven one. It is inclusive, involving diverse community groups, based on the principles of self-reliance, fulfillment of basic needs, and an emphasis on quality of life.

• **Long-term Perspective:**
It plans for 20 or more years, not for 2. It weaves together and balances considerations of economics, environment, and culture, including architecture and aesthetics that sustain a high sense of pride for the people.

• **Protection of Natural Environment and Culture:**
It integrates the wisdom of the past and connects this wisdom to the design and planning of a high quality future.

• **Center Focus:**
To minimize sprawl, it promotes in-fill, compact development, and the enhancement of community and business centeredness. New development should take place in existing urban, suburban and rural areas before using more open space. Greenbelts and Greenways should be used.

A very complete reference web site is: www.ciwmb.ca.gov/GreenBuilding.

► *Why is it important for tribes to adopt green building and energy practices?*

People want a better vision to move towards: As we look around our tribal communities there is an apparent lack of vision, tradition and deep pride in the built environment. Many express a feeling of loss, and wonder why are we not building with pride for seven generations?

The green building movement has been sweeping the construction industry for the past 18 years, but the techniques it promotes have only recently become common practice. The US Green Building Council www.usbg.org has been on the forefront of this movement thanks to their LEED (Leadership in Energy and Environmental Design)). It is the first widely-accepted set of guidelines for green building design and construction. The LEED Green Building Rating System® is a voluntary, consensus-based national standard for developing high-performance, sustainable commercial buildings, and now (2007) LEED-H residential buildings.

Green building provides a better alternative in responding to the many pressures that tribes and citizens are faced with, including rising energy costs, increasing population needs, scarce resources for maintenance and building replacement.

1. Economical reasons:
Though many decisions makers feel forced to make short-sighted decisions to build unsustainably, in the long-term it costs more money in higher maintenance, sooner replacement, higher health costs from poor indoor air quality, and higher vandalism and crime from lower feeling of well being of the residents and community due to buildings they are not proud of. Cheap energy won't last and homeowners and businesses are going to be hit hard by increasing energy bills - wishing they would have built to energy-wise standards.

2. Environmental reasons:
The way development is sprawling across the land is creating unsustainable habitats for people, land, and creatures. All the energy this sprawling, automobile-dependent living requires is causing global warming. Sprawl development takes up much more land than needed, and makes it hard for people to act in community harmony. Much land is abused or neglected because it was left out of planning circle.

3. Social reasons:
Tribes depend or their continued existence on local culture, values, aesthetics, design, materials. Solid families and communities able to interact in harmony are essential. Just as a location is unique on earth, it is good for the people who live there to be uniquely tied to that place as a unique and living place. Does the layout and design knit your families together as it should? Green planning and development will assure a collaborative process happens.

4. Health reasons:
Many diseases of the heart, lungs, skin and organs are increasing in the population. As we make out buildings tighter to save energy, we can become sicker from living in buildings with unhealthy conditions (see Sick Building Syndrome in Appendix). Green building practice assure indoor air quality is considered in building, and that buildings and communities are more "livable", and thus people are more healthy and productivite.

5. Regulatory reasons:
In modern society, those doing the building are not those living in the buildings or benefiting from better green standards. Tribes as sovereign nations have an advantage of adopting smarter (sustainable) practices ahead of the state or national system. You need to represent true needs of citizens vs. defending builders. Note: from the builders perspective they will act only if it is demanded by clients or regulators, and the time is right for this now. Builders actually admit it is OK to regulate the higher standards, as they get fewer call backs which saves them time and money. There needs to be a transition effort, but it is worth it to transition.

► *How does green building differ from normal standard building?*

There are some practices to move away from as we form a better vision of development:

1. Function:
- Standard building practices are determined by national standards focused on basic functions and safety of buildings as regulated for builders.
- Green building considers the whole living environment from the resident's point of view: a building not only must house them in basic comfort, but also should look good from cultural aesthetics, have good light and be healthy to live in, and cost little for energy, water and maintenance so people have money left for other needs.

2. Quality and Durability:
- Standard building practices only have to meet practices that have assumed energy will remain cheap and abundant. Most buildings are built in such a way that major repairs and remodeling will be required within a generation's time. If these buildings are tested with blower-door and

duct testing equipment and infrared cameras, most show significant areas of energy loss. Quality control is not rigorously enforced, and building methods are used which are hard to get high performance from.

- Green building practices stipulate many guidelines to assure higher quality, durability and performance.

3. Healthy to individuals and environment:

- Standard building practices assume any product sold by suppliers is OK to use in buildings. Many of these materials give off gasses that are toxic if breathed over time inside of tight buildings. [Refer to "Sick Building Syndrome" article in the attached Appendix.]
- Green building practices stipulate many guidelines to assure only healthy materials, glues, and paints are used, and that buildings have systems to circulate enough fresh air for occupants.

4. Aesthetically appealing:

- Standard building practices pay no attention to designing buildings to fit well with culture or to give occupants a sense of pride in place. Most plans come out of standard plan books and are not even adjusted so the building faces the best views or site conditions.
- Green building practices stipulate that local leaders, community members, and the actual residents of buildings meet together in the visioning and design process to preserve and create a sense of place and pride in building developments. Meaningful design can be incorporated and local materials used.

What are major concerns in adopting green building practices?

1. Lack of training:

- Green building often will require that the building trades people learn new ways of doing things. Contractors will have to learn about new standards, new materials, and new procurement sources. Subcontractors that are new to green construction practices will have to be trained to make sure they understand proper installation practices for these green measures.
- It is important to train homeowners about how their green built homes work and how to maintain its proper functioning. This may be done through a combination of public education workshops, building walk-throughs, and owner/occupant manuals.

2. Lack of regulatory support:

- Building contractors and vendors need to be given new standards for construction practices and materials. Tribes should adopt building codes with new more rigorous standards. Trained building inspectors are needed to assure compliance with the new codes and standards. Taking quality assurance one step further, buildings need to actually be tested for performance according to building science principles (including USGB Energy Star Home standards), to determine Envelope Leakage, Duct Leakage, Outdoor Air Flow Test, Supply Air Flow Test, and Local Exhaust Test.

3. Concerns about affordability:

- A common reason give for not building better quality sustainable housing and buildings is that it costs more money. This is not true when you look at the whole cost of living in a home or building which includes rent or mortgage, utilities, maintenances costs, and the equity value retained over time of a durable building. If you count the benefits of less sickness and greater human productivity from living in a healthy and aesthetic environment, the costs are even lower.

- Typical community houses can cost the same to build green, especially when builders are familiar with green building techniques and products and are building multiple buildings at the same time. When citizens who will be living in the home are consulted, they definitely choose green homes as being more affordable, because they also count savings in low energy, durability for low maintenance, fewer health issues & better quality of life. It is thus important for tribes to consider client's decisions in paying for values. It has also been demonstrated to save money for builders because green homes have greatly reduced costs to contractors due to fewer call backs.
- Banks and mortgage companies need to adopt programs recognizing the greater performance value over the long term of green homes. They need to increase valuation, and extend mortgages periods because the buildings are more valuable and durable. Insurance companies need to lower rates for safer, less fire prone green buildings.

NOTE

The following sections, Parts 1- 8, are presented in the form of lists of items that are meant to educate and stimulate thought about how to build more sustainably. Remember, if it is your home of office you would appreciate these features, therefore, try to accommodate as many items as practical in projects you help develop.

Solid round bullets (●) are statements of fact; Hollow box bullets (□) are suggested actions.

LAND & COMMUNITY PREPAREDNESS

Growing population pressures and development sprawl put a lot of pressure on the land. Community services and government support are stretched thin, and will be taxed further in the future as fossil fuels become less abundant and more expensive. To protect and enhance quality of life we must rethink the way we design communities and site buildings.

PART 1. SUSTAINABLE DESIGN and SITING

REGIONAL and NATIVE DESIGN and DURABILITY PLANNING

Though people typically think green building starts at the building site, it is very important to first consider the bigger community picture; to think community first and site second. Quality of life for people is very dependent on "the built environment" and this involves much more than just the home or office buildings where we spend most of our time. Communities are about relationships between people and between people and their surroundings. In the past 80 years our relationships have been mostly determined by the automobile - so we have designed our neighborhoods, towns and cities so cars can get between it all. However, our relationships with neighbors and to the land around our buildings has suffered by most accounts.

Throughout history, most major cultures express their philosophical and political ideologies best in its buildings and community plans. Many things can be determined by a people's architecture, such as the social structure, the relationship between the land and people, and even the psychological well being of the tribe. • What would archaeologists 500 years from now have to say about your tribe as they uncovered the remains of a standard subdivision? • Would they be able to describe the true passage through time of a great people?

Generally tribal members want homes, schools, and other buildings designed in a way that is more culturally sensitive to their natural environment and to their culture. They value ecological concepts of habitat for humans and other life over the long haul. Our built environment strongly shapes and affects our social environment and quality of relationships and our economic functionality. Instead of just incrementally adding more buildings that sprawl across the land, we can "look down" with an aerial view of the landscape and wisely select where durable infrastructure and buildings should best be placed for very long-term community and ecological function. If we build well from the start, it will save a great deal of money and energy in the future because we won't have to mitigate problems and replace the infrastructure again soon. All aspects of infrastructure and building design and materials should not be built just to minimum (short term) standards, but to long term standards of economic, ecological and social sustainability standards. We should build for the worst wind, storm water, and fire situations that may hit sites and structures. This may determine the need for alternative building systems for roofs and walls that are more durable.

Climate-responsive design involves designing built environments that respond to the natural environmental conditions of a location, which include temperature, humidity, wind, and solar radiation. The building design responds to these climatic conditions in siting, orientation, form, fenestration (wall design), materials, and landscaping.

Geomorphological aspects (shape of the land, elevation, aspect to the sun, land features) determine good places to put buildings and infrastructure to accommodate long-term natural watershed phenomenon of water/flood flow, plant community and soils development, wind and fire patterns, and animal habitat and movement.

INTEGRATED PROJECT PLANNING/ LOCATION and LINKAGES

At the beginning of any development project, select an integrated project team of diverse stakeholders, including planners, building officials, contractors, architects, and affected leaders.

- ☐ Meet together and choose a building standards program and a rating system.
- ☐ Choose third party rating inspectors who will inspect essential elements of project progress.
- ☐ Ensure that development fits within a responsible local and regional planning framework.
- ☐ Carry out mixed-use development to enhance community interaction and service access.
- ☐ Hire a landscape architect to help with siting of building and infrastructure.
- ☐ Assess regional climatic conditions.
- ☐ Investigate microclimate (specific variations from regional climatic conditions).
- ☐ Research past human uses of the proposed site, and concerns for long-term cultural fit.
- ☐ Investigate site for agricultural potential and past agricultural uses.
- ☐ Create a map of physical elements on the site (structures, topography, soils, hydrology).
- ☐ Create a map of vegetation on the site, including notation of significant speciments.
- ☐ Create a wildlife/habitat survey, including links to offsite habitat corridors.
- ☐ Carry out a careful wetlands survey.
- ☐ Identify most degraded or ecologically damaged areas of the site.

Those with "local knowledge" of an area can provide valuable information on the site conditions and changes that have occurred over time in addition to an ecological site assessment.

- Decisions for development should be based on topography, solar access, site drainage, and local climate.
- Protection of significant environmental and cultural features needs to be clearly understood and stated in the design and construction phases of new development.
- New development provides and opportunity to restore areas of a site that have previously been damaged.

- ☐ As possible, add new building on the edge of current development. Select previously developed sites or infill sites between current buildings.
- ☐ As possible, keep new building within ½ mile of existing water, power and sewer lines.
- ☐ As possible, build near public transportation hubs, and assure parks or green open spaces are nearby.
- ☐ Use the community design and building placement process to honor socio-cultural values: honoring the character of place: plants, food, gardens and places for animals included; traditional ceremonial sites included; social justice to all community members considered.
- ☐ Use community design elements to best integrate needs of diverse ages of all residents.
- ☐ Plan the placement of buildings to enhance security, reduce crime, and create community interaction.
- ☐ Design homes to be adaptable for home office use.

- ☐ Be sure to consider natural community centers where people can meet to maintain desired relationships within short distances.
- ☐ Design development to have pedestrian emphasis rather than automobile emphasis. Automobile traffic and parking needs to be planned to not threaten human values or safety.
- ☐ Provide safe access for bicycles and provide storage areas for bicycles.
- ☐ Provide access to public transportation, and vehicle assess to support car and vanpooling.
- ☐ Incorporate traffic-calming measures (narrower streets, medians, etc.).
- ☐ Include parks and open spaces and protect them far into the future.

PREFERRED LOCATIONS

- ☐ Avoid contributing to sprawl; fit project well into existing community.
- ☐ Select already developed sites for new development. Select building sites that make use of exiting infrastructure.
- ☐ Look for opportunities for infill development.
- ☐ Select brownfield sites for clean-up and development.
- ☐ Look for a property where infrastructure needs can be combined.
- ☐ Avoid environmentally sensitive sites and good farmland.
- ☐ Avoid building on flood-prone property. Don't build within 100 year flood plains or habitats of threatened or endangered plant and animal species.
- ☐ Avoid building on or degrading wetlands. Don't build within 100 feet of any water, including wetlands.
- ☐ Avoid building where damage to fragile ecosystems cannot be avoided.
- ☐ Avoid properties that interfere with wildlife corridors.
- ☐ Avoid damaging significant historic or prehistoric sites.
- ☐ Avoid developing on prime agricultural land.
- ☐ Avoid hilltop properties.
- ☐ Avoid properties with excessive slopes.
- ☐ Avoid non-sewered sites if environmentally responsible on-site systems is not feasible.
- ☐ Avoid sites that would require excessively long and excessively damaging access roads.
- ☐ Locate buildings on the most degraded parts of the site.
- ☐ Site buildings where lowest biodiversity is present, in away to protect significant ecosystems.
- ☐ Site access roads or driveways to help maintain identifiable edges on the property.
- ☐ Site buildings to minimize visual impacts, including from roadways and neighboring buildings.
- ☐ Follow natural contours with roadways, utility lines, etc.
- ☐ Protect and celebrate a site's uniqueness, so as to help occupants celebrate the natural beauty.
- ☐ Site building(s) were existing vegetation can reduce energy use.
- ☐ Provide for solar access.
- ☐ Avoid building on shrink-swell soils.

LAND and PROJECT DEVELOPMENT

- ☐ Cluster buildings to preserve open space and protect habitat.
- ☐ Celebrate and enhance existing landscape features.
- ☐ Minimize development impact area.
- ☐ Minimize building footprint.
- ☐ Restrict vehicle access during construction to reduce damage to vegetation and soils.
- ☐ Fence off a wide area around trees to be protected.
- ☐ Avoid storage of building materials or soil in areas where tree roots could be damaged.
- ☐ Investigate government programs to assist in remediating brownfield sites.
- ☐ Decontaminate brownfield sites and rebuild degraded soils.
- ☐ Establish long-term relationship with responsible excavation and sitework contractor.
- ☐ Institute a reward or penalty system to provide incentive for contractor to protect site.
- ☐ Designate appropriate staging areas for construction-related activities.
- ☐ Schedule construction carefully to minimize damage to vegetation and ecosystems.
- ☐ Minimize soil erosion from construction activities.
- ☐ Limit parking area and disperse parking to avoid flattening large areas.
- ☐ Use the smallest excavation and sitework machinery that will do the job.
- ☐ Stockpile topsoil during the excavation and sitework.
- ☐ Avoid grade change around trees; provide large enough terracing to protect roots.
- ☐ Tunnel under trees for utility lines.
- ☐ Before concrete pours, designate a location for cleaning out concrete trucks.
- ☐ Use light-colored pavement to reduce heat island effect.
- ☐ Integrate on-site wastewater treatment system with landscape design.
- ☐ Avoid burying woody debris near buildings.
- ☐ Design buildings to provide easy visual inspection for above-ground termite tubes.
- ☐ Use the least toxic treatment methods and materials for pest control around buildings.
- ☐ Prevent termite access to structure and use bait system for termite control.

STORMWATER

- ☐ Minimize width and length of roadways.
- ☐ Reduce driveway pavement.
- ☐ Use planted swales instead of curbs and gutters.
- ☐ Avoid contiguous impermeable surfaces and locate disperse parking areas.
- ☐ Consider porous turf-paving systems on low-traffic parking and driveway areas.
- ☐ Install gravel paving in a matrix to retain permeability.
- ☐ Use modular block paving or install porous asphalt or concrete.
- ☐ Contour slopes for reduced runoff.
- ☐ Incorporate surface infiltration basins and landscapes, and use subsurface infiltration basins.

LANDSCAPING

- ☐ Minimize turf areas; convert turf areas to native desert, prairie, or woodland ecosystem.
- ☐ Remove ecologically damaging non-native (invasive) species.
- ☐ Keep landscape buffers along streams with native vegetation.
- ☐ Install erosion control structures to protect buildings and soils during and after construction.
- ☐ Avoid or minimize cut-and-fill and keep soil materials on site.
- ☐ Salvage native plants during construction.
- ☐ Replant damaged sites with native vegetation.
- ☐ Landscape with indigenous vegetation; as possible with useful forbs, shrubs, trees.
- ☐ Landscape with plants that provide wildlife forage or habitat.
- ☐ Use plantings to stabilize soils and control erosion.
- ☐ Plant trees to shade parked vehicles.
- ☐ Install hardy trees and shrubs to shade hard surfaces and reduce wind force, thus tempering the home's outdoor environment.
- ☐ Keep plantings somewhat away from buildings to minimize insect entry.

▶The use of indigenous (or native) landscaping provides a number of benefits - environmental, social, aesthetic, and economic. Environmentally, native plants are able to grow in the climatic conditions that exist naturally in that region, therefore they require less use of water resources. They provide ling-term landscape stability and sustainability, increase biological diversity, enhance groundwater recharge through increased absorption, regenerate organic soil, reduce erosion, reduce downstream flooding, preserve and/or restore existing plant and seed banks, improve air quality through carbon fixing in the soil, and improve water quality through the filtering of dirty water.

▶Socially, integrating native plants into conventional landscaping creates a strong sense of place and regional pride, promotes a sound development ethic, provides public education and interaction opportunities, develops aesthetic richness, and provides emotional and psychological relief from the built environment.

▶Economically, native plants significantly reduce maintenance and infrastructure costs at comparable installation costs, and reduces the need for pesticides. Ecological site planning and design can enhance community and culture through the inclusion of design elements that promote interaction and create a pleasant public environment. This can be realized by providing open space for agriculture and recreation as well as general landscaping and natural habitats.

REDEVELOPMENT and REMODELLING

Instead of always building in new locations while neglecting the old, consider remodeling with new green technology.

- ☐ Overlay new plans on old developed areas, use life-cycle planning of existing buildings and infrastructure to start reshaping community and sites to form a sustainable community model incorporating historic structures and mixed-use values.
- ☐ Infill new structures with the old and gradual shift infrastructure and connectivity for pedestrians, and outdoor meeting areas.

Sustainable Siting and Design

Building projects can have a huge influence on their local environment, both positively and negatively. Issues such as where a building is sited or how the whole building project (including roads, parking, landscaping, etc.) is integrated with its surrounding environment and community are critical. Using local climate, sun, wind, and shade to maximum advantage are key siting elements. While not all of these issues are relevant to every project, considering each can help the Tribe develop buildings that fit seamlessly and naturally within their natural environment and community.

Each project's particulars will determine if addressing these siting issues will add costs. For example, some sustainable building options may reduce cost (for example, by moving the project to a lower value, previously developed "brownfield" in an urban or suburban location) or may increase cost (for example, by involving expenditures to safeguard land as open space). The most important thing is to consider these alternatives and to explore opportunities for win-win design changes that further sustainable building goals and reduce cost.

SITE SELECTION

Frequently, a building site has already been established and site selection is not an option. However, here are several issues to consider when the site has not yet been determined or the location and orientation within the site have not yet been determined.

Use appropriate building sites. Ideally, unless they are specifically part of a newly planned expansion designed according to sustainable development principles, new building projects should avoid the need for new roads, parking areas, or buildings on prime farmland or wildlife habitat; land whose elevation is within or near the 100-year flood plain; land within 100 feet of any water, including wetlands; or land that was previously open space or public park land. Tribes developing properties within or near California municipalities may choose to voluntarily adhere to the established land use policies for that community, or to meet the spirit of the policies in creative ways. As a general rule, promoting sensitive infill consistent with local plans and infrastructure is environmentally preferable to creating a new development requiring new infrastructure or services.

Sustainable Siting and Design Issues

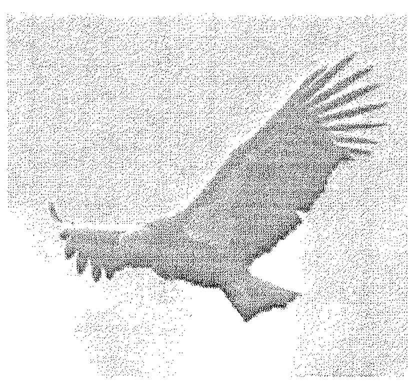
SITE SELECTION	SITE INTEGRATION
• *Use appropriate building sites.*	• *Enhance naturally occurring biodiversity.*
• *Preserve open space.*	• *Minimizing site disturbance.*
• *Reduce sprawl.*	• *Manage stormwater.*
• *Develop brownfields.*	• *Optimize transportation options.*
• *Safeguard endangered species.*	• *Reduce heat islands.*
• *Restore damaged environments.*	• *Reduce light pollution.*
• *Design to optimize sun, wind, and light.*	

Preserve open space. Consider incorporating the preservation of open spaces—undeveloped land and resource areas—into your building project while avoiding impacting previously undeveloped open spaces. For example, projects may establish a conservation easement or donate adjacent lands to a local land trust or open space district. If open spaces must be developed, consider donating an equivalent amount of land elsewhere to open space status.

Reduce sprawl. Consider channeling the new building to previously developed areas with existing infrastructure wherever possible, while protecting green fields (natural or park areas) and preserving habitat. This is most relevant to developments in established suburban or urban environments, where the danger of sprawl is most apparent. But even in rural areas, consolidating residential development through "clustering," for example, can produce vibrant communities with stores and services located within walking distance. At the same time, this practice reduces transportation needs and the potential for future sprawl patterns.

Develop brownfields. Where possible, consider rehabilitating abandoned buildings and sites. As defined in federal law, (42 U.S.C. 9601) a brownfield site is real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant. Such sites must be thoroughly evaluated by a qualified environmental firm, with a rehabilitation plan established, but should be considered. Developing brownfields allows the cleanup and recycling of existing infrastructure while preventing degradation of undeveloped land.

Safeguard endangered species. Avoid entirely any land or wetlands specifically designated as habitat for an endangered or threatened species. Conducting a detailed inventory of plant and animal species is critical. Once identified, the presence of endangered species may necessitate changes to the project that are hard to predict ahead of time. Once complete, information about threatened and endangered species living in harmony with a new building project can serve to tighten the connection between building users and the natural environment.



Restore damaged environments. Some building projects may provide the opportunity to restore damaged lands to a natural state, such as conversion of gravel parking lots to fields, meadows or wetlands, or replanting trees or native grasses.

Design to optimize sun, wind, and light. The beneficial impacts of designing a building around its local climate and topography to achieve desirable sun, wind, and light patterns can be quite impressive. For example, orienting a patio to provide a beautiful view, placing it outside of typical wind patterns, or orienting glazing to provide views of a sunset can make a huge difference in the qualitative feel and comfort of a building. These elements also impact energy use by affecting ventilation, lighting and heat flow, of course, and so should be considered along with these factors. The design should also consider the impact of the new building on the surrounding environment and on neighbors.

SITE INTEGRATION

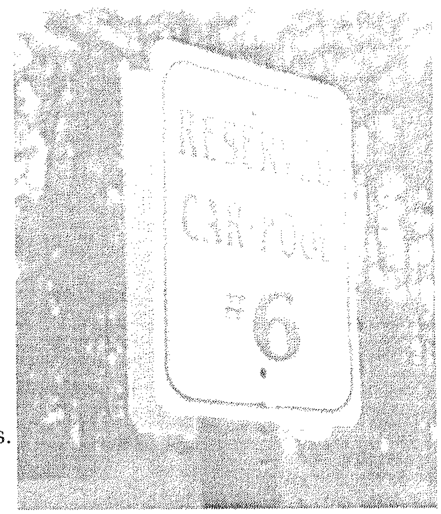
Regardless of whether a site has already been identified, the following steps can aid in integrating the building project into the local environment and community.

Enhance naturally occurring biodiversity. Consider first maintaining and enhancing naturally occurring biodiversity on the site. Design the site to reconnect fragmented landscapes and establish contiguous networks with other natural systems both within the site and adjacent to it. For example, a corridor of trees might be incorporated into a project to connect two adjacent forest areas. Avoid major alterations to sensitive topography, especially removing or relocating natural vegetation and wildlife habitat. Establish car-free areas exclusively for foot traffic, with information about local species, to promote appreciation of the natural environment.

Minimize site disturbance. During construction the contractor team will need to take steps to minimize impacts to the natural environment. Issues of concern include degradation of water quality through pollution or siltation, damaging soils through digging or mixing foreign materials, and spills of hazardous substances. These can be minimized by adopting a thorough site management plan including, for example, clear directions for all parking and operations by construction workers.

Manage stormwater. Stormwater runoff is a serious concern both during and after construction. The problem arises because naturally porous vegetation is replaced with impervious surfaces like roofs, roads, and parking lots. This causes far higher flows into local streams with high amounts of silt and potential pollutants from construction vehicles or building operations. For previously developed sites, consider restoring paved portions to natural or adapted vegetation, and ensure that the post development imperviousness is less than the pre-development imperviousness, as measured by a 24-hour peak discharge rate. For all building projects, consider mitigating stormwater runoff problems by maximizing the use of porous surfaces or by capturing runoff. Examples of porous materials include rooftop vegetation, paver blocks or large aggregate concrete instead of pavement or asphalt, and crushed stone or brick for pedestrian paths. Examples of capture systems include channeling runoff to natural or constructed wetlands or using a rain water catchment system enabling use of the water for irrigation over time. (See Module 7, Water Efficiency and Landscaping.)

Optimize transportation options. Ideally, a building will include steps to maximize convenience and minimize transportation energy and time required by building users. Strategies include siting new buildings near public transportation or negotiating new access to existing public transportation services. Building projects can promote alternative transportation by including bicycle access, covered bike racks, and showers with lockers. Parking lots can include spaces with electricity or natural gas recharging capacity for alternative fueled vehicles. In commercial buildings, the best parking spots can be reserved for carpools.



Reduce heat islands. Heat islands are portions of building developments that tend to be much hotter than the surrounding undeveloped areas, and they can have a detrimental impact on the microclimate, on wildlife habitat, and on human comfort. Heat islands can be mitigated by providing shade from trees or roofs with highly reflective surfaces. Also, consider replacing or lining constructed surfaces (that is, rooftops, sidewalks, or roads) with vegetation to the extent possible to reduce heat absorption. Another option is Energy Star rated roofing materials. (See Module 8, Energy Efficiency.) Some California communities have a 51 percent shade canopy requirement for parking lots that the Tribe may consider adopting.

Reduce light pollution. Ideally, new buildings will be constructed to reduce or eliminate light trespass and improve night sky access, thereby reducing the development impact on nocturnal environments. This can be accomplished by reducing the intensity of external night lights (thereby reducing energy use as well), by limiting the height of buildings, and by covering or partially shading bright lights.

ENERGY PREPAREDNESS

Commonly used energy in the form of gasoline, oil, natural gas, and coal have passed their peaks of production in the US and most places in the world. Current and future generations will face decreased supplies of energy and increasing costs. Green design and building provide excellent ways reduce energy requirements while making our buildings and community settings more comfortable and functional.

PART 2. ENERGY EFFICIENCY and ATMOSPHERE

Life requires energy - from the food we eat, the fuel we use to travel, and the fuel and power we use to heat, cool and light our homes, schools and community buildings, and workplaces.

- One third of all energy used in North America is used to heat, cool and operate the buildings we live and work in.
- For life and well being we need energy security - energy is going to cost more as time goes on and oil and gas become less abundant.

ENERGY CONSERVATION

Consider energy conservation first before deciding to build on new passive or active energy use platforms.

- Any new or remodel project should follow US Energy Star standards. Such buildings will use 15 to 20 percent less energy than a comparable home built to the 2004 International Energy Conservation Code. Certified Energy Star homes Use Energy Star appliances, efficient Energy Star rated HVAC systems, and daylighting.
- Current buildings can have life cycle analysis and duct and whole house blower testing done to show where low-cost improvements can yield substantial savings.
- Building users can receive training on energy conservation habits of only using lights when and where needed, changing light bulbs to low energy bulbs, using less hot water, and setting heating and cooling system controls for proper temperatures at different times of day.

PASSIVE SOLAR DESIGN

When building new buildings and doing major remodeling, focus first on passive energy design.

- Passive solar design is climatic design using free and abundant natural energies and daylighting.
- Efficient design not only saves energy (buildings can be built that use almost <u>no</u> energy for heating or cooling), they also feel better.
- Passive solar components need little if any maintenance and do not add green-house gases to the environment.
- With few cloudy days, Arizona offers the best opportunity in the US for solar energy use.

PASSIVE SOLAR DESIGN - *Sun-Tempered Design*

Sun-tempered buildings are the simplest and least expensive (need cost no more to build than standard construction) passively heated buildings. Sun tempered buildings are achieved by orienting the east-west axis of the building to true south and by modest increases in the number of windows on the south side (obtained by reducing windows on the east, west, and north sides)

- Glazing area: < 7% of Finished Floor Area (FFA) on south face; < 2% of FFA on west face; < 4% of FFA on east face; < 4% of FFA on north face; Skylights less than 2% of finished ceiling area, with shades and insulated wells; Overhangs designed to provide shading on south-facing glass (at a minimum), or adjustable canopies or awnings.

Building considerations include proper Size and Floor Planning, Building Orientation, Glass Placement, Mass Placement, and Insulation (see the sample floor plan at the end of this section):

1) Size and Floor Planning

Design compact buildings where each room is heated directly or is accessible to solar heat.

- Since the 1950s, living area per family member has increased by a factor of 3 (despite shrinking family size), and this has distorted social views and expectations of what is needed to be comfortable.
- More compact and simple building forms with good insulation values were understood by traditional builders of the past.
- The various forms of traditional homes in both low and high desert areas have been simple and compact with a large central space, having a small surface-to-volume ratio to reduce heat loss in winter and heat gain in summer.
- The biggest savings of money in materials, energy and maintenance is to build compact structures that are no bigger than needed for the intended functions.
- ☐ Before selecting a floor plan, clearly list the kinds of uses needed in the building.
- ☐ See how uses can be put together to reduce the number of rooms needed (use open floor plans and great rooms; keep utility areas together; reduce hall areas).
- ☐ In determine the shape of the building (long, square, round, rectangle, two story, etc.) consider how daylighting and solar heating will work best, how rooms insulate each other, and how efficient foot traffic patterns will be.
- ☐ Where possible build storage and shelves into walls. Plenty of well designed storage can save a great deal of energy and money over time by allowing bulk purchase of groceries an supplies and saving trips to the store.
- Generally, half of the rooms in a home need cooler temperatures (bedroom and storage areas) and half need warmer temperatures (living, dining, cooking areas). A tremendous amount of energy will be saved over the life of a home if cool areas are put on the north.
- ☐ Layout cool rooms on the north side of the building and warm rooms on the south.
- Outdoor spaces such as porches, patios, ramadas, gardens and public plazas can allow living out of doors much of the year - thus indoor areas can be smaller and more energy efficient.
- ☐ Design outdoor living areas that reduce the space needs for indoor area.

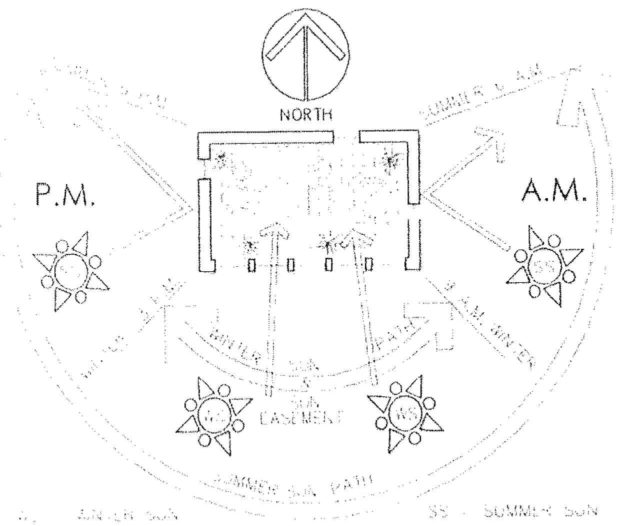
2) **Building Orientation**

Choose a building site with good solar exposure.

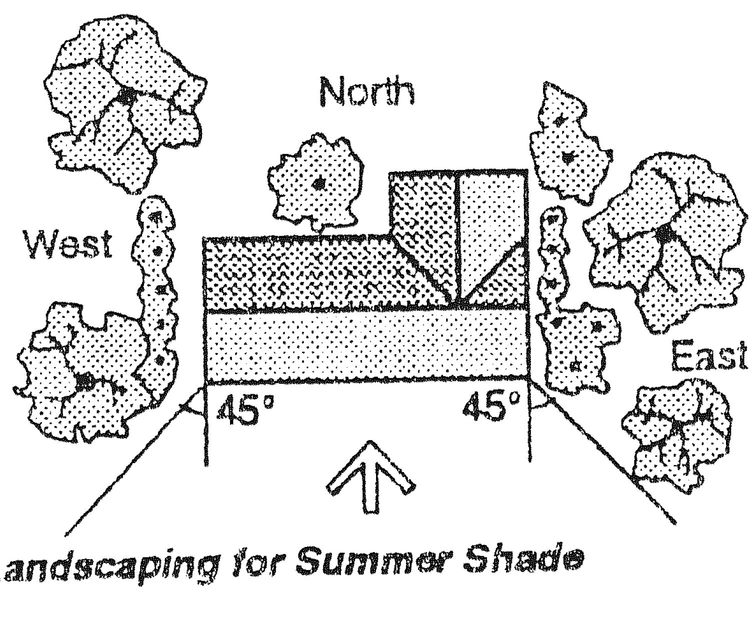
- Building sites need unobstructed access to sun from 9 AM to 3 PM or at least 10 AM to 2 PM during the heating season. Carefully consider how the building should be oriented for best access to sun as well as prevailing air flow.
- Orient the long axis of buildings within 15 degrees of due south, with a bias for the east where early morning heating is desirable.

☐ East-west street designs work well, so long as garage placement does not block solar gain.

☐ North-south street or oblique street designs can work well by keeping garages on east, west, or north sides of buildings.



PROPER ORIENTATION TO THE SUN
IS IMPORTANT YEAR-ROUND



Landscaping for Summer Shade

3) <u>Glass Placement</u>

Locate most windows on the South side of the house; minimize windows on the North, East, and West sides. Provide overhangs and shading to regulate solar gain (refer to Building Envelope below).

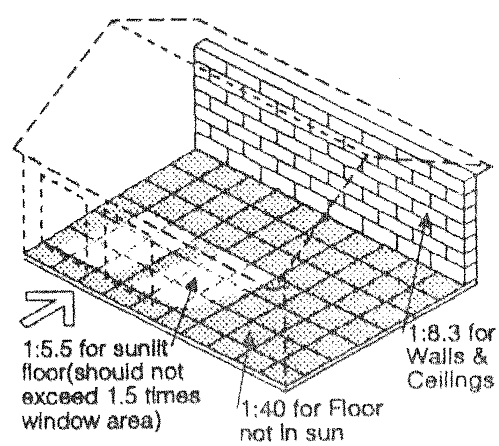
- Window glass allows sunlight into rooms for natural lighting, and natural heating (via the greenhouse effect of converting UV energy to heat).
- Negative effects of window are 1. they have very low R-values so can loose a lot of energy, especially at night, 2. they can overheat rooms if too much glass faces east, south or west, and 3. they can produce uncomfortable glare and fade fabrics on east, south or west walls.
- To mitigate the negative effects and reap the positive do the following:
  - Use windows that meet Energy Star for Windows standards with ultraviolet films rated for wall directions and proper pane of glass.
  - Low solar-heat-gain-coeficient(SHGC) glazings should be used on east and west orientations, while high SHGC glazings make sense on south orientations where passive solar and daylighting are being used (including proper overhang shading design).

4) <u>Mass Placement</u>

Provide sufficient, properly situated thermal mass in buildings.

- Unlike furnaces that can come on anytime needed, sunshine only shines for part of the day.
- Solid mass is required inside of a building to store solar energy while the sun shines, for slow release for hours after the sun goes down. The air, hollow walls and wood or carpeted floors of standard homes do not supply enough mass for solar energy storage.
- While building solid interior walls, floors, fireplaces and other mass may be more expensive, it will save money over time in lower energy costs and, by being very durable, will last much longer with less maintenance cost.
  - For best cost-effectiveness, mass should be placed near south windows and as described in the following "Building Envelope" section.

High thermal mass allows a house to be more comfortable by absorbing the sun's direct heat as it enters in the winter and the indirect heat entering during the summer. Without thermal mass, the sun's heat can stay in the air and make the room feel too warm during the day. Heat in the air then escapes quickly through windows at night. Materials such as brick, stone, ceramic tile, and concrete hold heat well. Although it is best to have thermal mass in or near direct sun, adding more of it can compensate so long as the mass is in the same room as the direct sun.



5) **Insulation**

Insulate walls, ceilings, floors, foundations, and windows, and protect insulation from moisture.

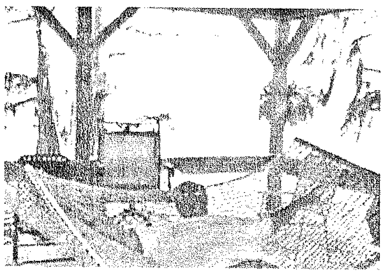
- Proper insulation is a key element for a more comfortable and energy efficient home. Most solar designers prefer wall insulation ranging from R-22 to R-30 and ceiling insulation of R-40 to R-50 and sometimes more in very cold climates.
- To save energy heat must be conserved and kept where we want it - kept inside on cold days, and kept outside on hot days.
- Due to the wide fluctuations of daily and seasonal weather, solid mass in buildings is not enough to keep rooms comfortable - insulation (which uses trapped air to slow heat transfer) is required to control heat transfer.

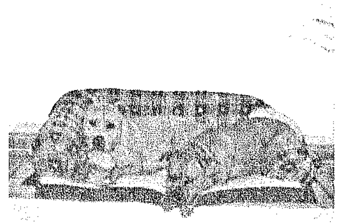
It important to have a continuous boundary of insulation between the conditioned, indoor spaces and the unconditioned, outdoor spaces.

- This boundary is called the "building envelope" and consists of walls, floor, and ceiling or roof.
- Low insulation levels and gaps or voids in the insulation materials can provide paths through which heat and air can easily flow into or out of the building. Greater insulation values will improve comfort, lower utility bills, and improve resale value of buildings.
- ☐ Take care to shape the insulation material around piping and electrical work without compressing it.
- ☐ Fiberglass insulation needs careful installation so it fits tight against the wall backing and there are no gaps on edges, at top, or around objects. Note that 5% area of gaps in a fiberglass insulated wall will reduce the labeled R-value by half!
- Due to the difficulty of meeting such high installation standards with fiberglass bats, solid sheet foam insulation and spray foam insulation are being used more now as more energy effective products.
- ☐ Be sure an inspector checks all insulation work before walls are closed in.
- ☐ An air leakage test can verify tightness of the building envelope.
- ☐ An infrared camera can detect insulation values of all surfaces.
- ☐ In cold climates it is recommended to keep insulation and envelope cavities dry (to prevent rot and mold) by applying a vapor retarder or low permeability paint to the warm side of the envelope.
- ☐ For best cost-effectiveness, insulation should be placed as described in the following "Building Envelope" section.

Comfort and Common Sense

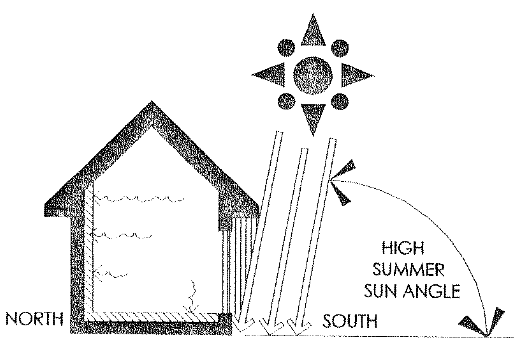
During hot summers, dogs lie in the shade on the cool earth beneath porches. On cold days, cats seek a warm chair in front of a sunny window. These simple solutions for staying comfortable are easy to incorporate into the design of homes. With proper window placement and house design, a house can stay cool in summer and warm in winter.



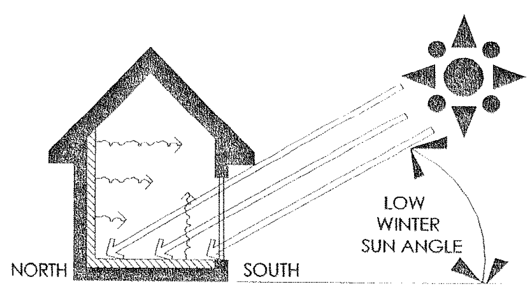


Sun-Inspired design and two simple facts

- **In winter,** the sun rises in the southeast, remains low in the southern sky, and sets in the southwest. Windows on the south allow the low winter sun to enter and warm the home.
- **In summer,** the sun rises in the northeast, climbs high in the southern sky, and sets in the northwest. Overhangs protect south windows from the high summer sun.



SUMMER SUN HIGH IN THE SKY



WINTER SUN LOW IN THE SKY

Sun-Inspired homes utilize the fixed components of windows, overhangs, insulation, and thermal mass to control the sun's heat and light that enters the house without active measures by people or machines. Used together, they create a passive system used for both heating and cooling. A "passive" system takes advantage of naturally occurring energy in its surroundings to serve a purpose without the aid of auxiliary mechanical equipment. These systems consume no threatened resources and produce no waste. The ample energy of the sun can be easily manipulated by passive systems to make homes more comfortable and energy-efficient.

Five Elements of Passive Solar Home Design

The following five elements constitute a *complete* passive solar home design. Each performs a separate function, but all five must work together for the design to be successful.

Aperture (Collector)

The large glass (window) area through which sunlight enters the building. Typically, the aperture(s) should face within 30 degrees of true south and should not be shaded by other buildings or trees from 9 a.m. to 3 p.m. each day during the heating season.

Absorber

The hard, darkened surface of the storage element. This surface—which could be that of a masonry wall, floor, or partition (phase change material), or that of a water container—sits in the direct path of sunlight. Sunlight hits the surface and is absorbed as heat.

Thermal mass

The materials that retain or store the heat produced by sunlight. The difference between the absorber and thermal mass, although they often form the same wall or floor, is that the absorber is an exposed surface whereas thermal mass is the material below or behind that surface.

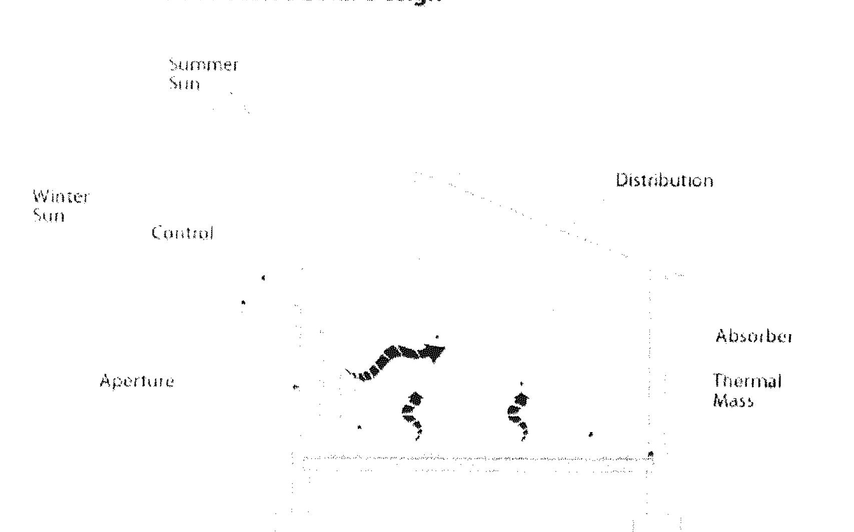
Distribution

The method by which solar heat circulates from the collection and storage points to different areas of the house. A strictly passive design will use the three natural heat transfer modes—conduction, convection, and radiation—exclusively. In some applications, however, fans, ducts, and blowers may help with the distribution of heat through the house.

Control

Roof overhangs can be used to shade the aperture area during summer months. Other elements that control under- and/or overheating include electronic sensing devices, such as a differential thermostat that signals a fan to turn on; operable vents and dampers that allow or restrict heat flow; low-emissivity blinds; and awnings.

Five Elements of Passive Solar Design



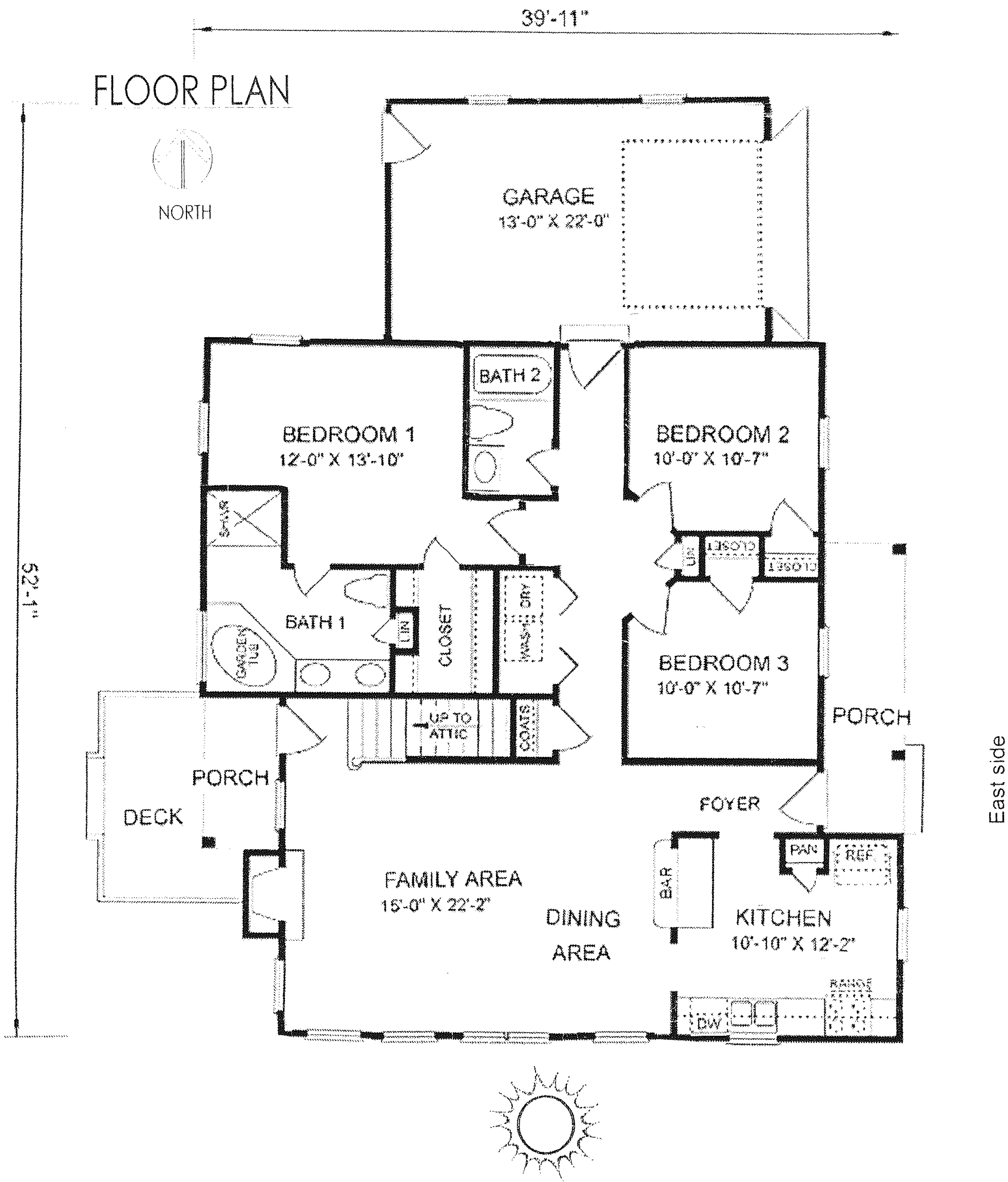
Sample Sun-tempered house design [Same cost as standard construction]

Square Feet:	1350	Width:	53'
Bedrooms:	3	Depth:	40'
Bathrooms:	2	Ceiling Height: Main Floor:	8'
Levels:	1		
Garage Stalls:	1	Available Foundations:	Basement, Crawlspace, Slab

Area

Main Floor:	1350
Garage:	286
Porch:	105

More by this designer

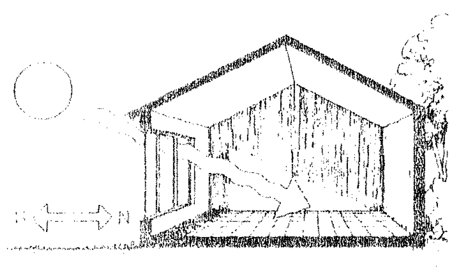


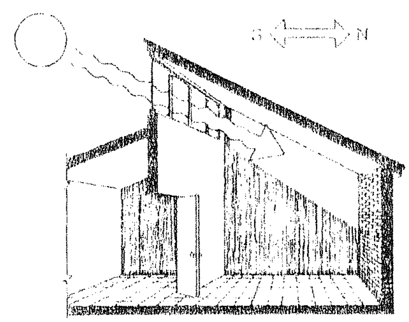
PASSIVE SOLAR DESIGN - Solar-Gain Design

Solar-gain buildings, or true passive solar designs, provide substantially more winter heat than sun-tempered buildings. To do so, designers place a greater percentage of a buildings windows on the south side (7-12% of FFA), and incorporate greater use of thermal mass.

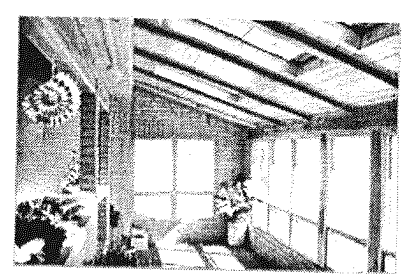
- This mass can be: walls of concrete, brick, stone, concrete filled block, or solid concrete block; floors of exposed concrete, tiles or pavers on concrete, or compacted earth; water stored in drums or culverts; a massive solid fireplace.
- This thermal mass inside the building needs to be at least 4 inches thick and works best if it is a dark color. Mass that gets direct sunlight on it is most effective in storing heat: it takes 5.5 square feet (SF) of mass in direct sun light to store the heat from 1 SF of glass; 8.3 SF of mass/SF glass in walls and ceilings; 40 SF of mass/SF glass in areas away from sun.
- A trombe wall is a south-facing thermal storage wall 8-24 inches thick, painted black, with glass directly in front of it. Some building design substitute up to 2/3rds of south windows with trombe walls so that heat is stored and released into the building without unwanted light and glare.

Direct Gain





Sun-space is a structure added to the south side of a building to collect and concentrate heat that can be channeled into the main building. A sun room or attached greenhouse can be used as a warm living area on cold days, and doors left open to warm the main building area on cold days, or closed off on warm days. The simplest and most reliable sunspace design is to install large vertical windows on a south room that has masonry floor and walls. Ceiling and floor level vents, windows, doors, and fans can be used to distribute the heat to the main house.



A sunspace or attached greenhouse relies primarily on convection to move heat from the sunny space to other adjacent rooms. Photo credit: Donald Aitken

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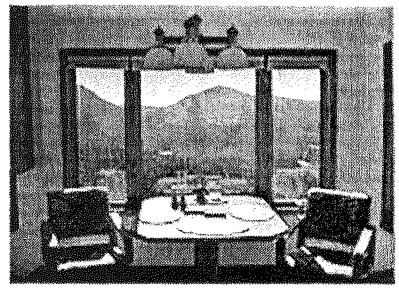
Direct Gain

Direct gain is the simplest passive solar home design technique. Sunlight enters the house through the aperture (collector)—usually south-facing windows with a glazing material made of transparent or translucent glass. The sunlight then strikes masonry floors and/or walls, which absorb and store the solar heat. The surfaces of these masonry floors and walls are typically a dark color because dark colors usually absorb more heat than light colors. At night, as the room cools, the heat stored in the thermal mass convects and radiates into the room.



This photo shows a mountain home in Colorado that uses passive solar heating, i.e., direct gain. Photo credit: Dave Parsons

Some builders and homeowners have used water-filled containers located inside the living space to absorb and store solar heat. Water stores twice as much heat as masonry materials per cubic foot of volume. Unlike masonry, water doesn't support itself. Water thermal storage, therefore, requires carefully designed structural support. Also, water tanks require some minimal maintenance, including periodic (yearly) water treatment to prevent microbial growth.

The amount of passive solar (sometimes called the passive solar fraction) depends on the area of glazing and the amount of thermal mass. The glazing area determines how much solar heat can be collected. And the amount of thermal mass determines how much of that heat can be stored. It is possible to undersize the thermal mass, which results in the house overheating. There is a diminishing return on oversizing thermal mass, but excess mass will not hurt the performance. The ideal ratio of thermal mass to glazing varies by climate.

Another important thing to remember is that the thermal mass must be insulated from the outside temperature. If the thermal mass is not insulated, the collected solar heat can drain away rapidly. Loss of heat is especially likely when the thermal mass is directly connected to the ground or is in contact with outside air at a lower temperature than the desired temperature of the mass.

Even if you simply have a conventional home with south-facing windows without thermal mass, you probably still have some passive solar heating potential (this is often called solar-tempering). To use it to your best advantage, keep windows clean and install window treatments that enhance passive solar heating, reduce nighttime heat loss, and prevent summer overheating.

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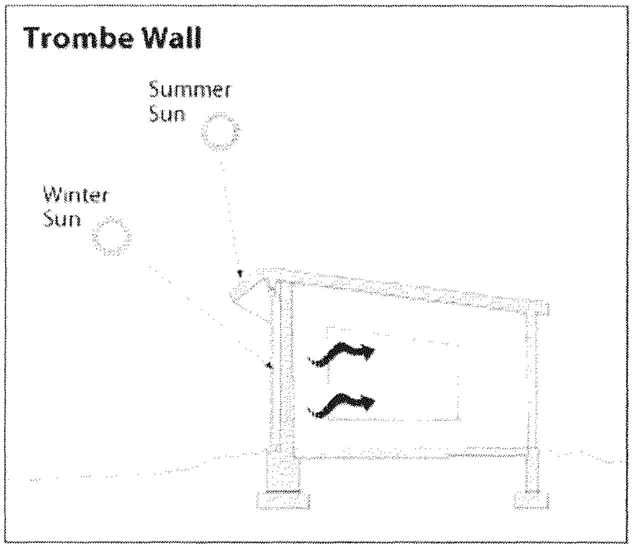
Indirect Gain (Trombe Walls)

An indirect-gain passive solar home has its thermal storage between the south-facing windows and the living spaces.



Using a Trombe wall is the most common indirect-gain approach. The wall consists of an 8–16 inch-thick masonry wall on the south side of a house. A single or double layer of glass is mounted about 1 inch or less in front of the wall's surface. Solar heat is absorbed by the wall's dark-colored outside surface and stored in the wall's mass, where it radiates into the living space.

The Trombe wall distributes or releases heat into the home over a period of several hours. Solar heat migrates through the wall, reaching its rear surface in the late afternoon or early evening. When the indoor temperature falls below that of the wall's surface, heat begins to radiate and transfer into the room. For example, heat travels through a masonry wall at an average rate of 1 hour per inch. Therefore, the heat absorbed on the outside of an 8-inch-thick concrete wall at noon will enter the interior living space around 8 p.m.

Learn More

Reading List

- Crosbie, M.J., ed. (1997). *The Passive Solar Design and Construction Handbook*. New York: John Wiley & Sons, Inc.
- *Passive Solar Design* (PDF 233 KB). (December 2000). DOE/GO102000-0790. Work Performed by the NAHB Research Center, Southface Energy Institute, and Oak Ridge National Laboratory. Washington, D.C.: U.S. Department of Energy.
- Kachadorian, J. (1997). *The Passive Solar House*. White River Jct., VT:

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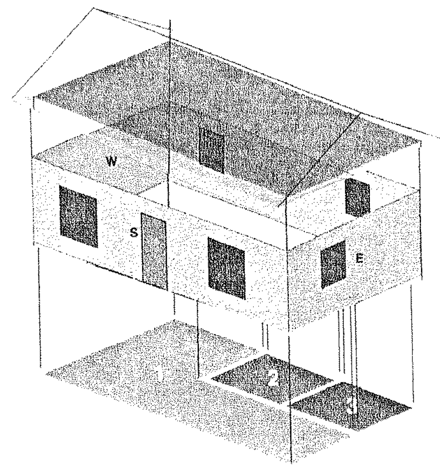
BUILDING ENVELOPE

The emphasis for energy efficiency is placed on the building enclosure, which is also called the building envelope. The envelope includes not just the walls but all six sides:



1. FOUNDATIONS

- ☐ Use crawlspace insulation with a whole-system insulating value of R-10; the closer to R-26 the better.
- ☐ Use basement wall insulation with an R-5; the closer to R-10 the better. Insulate foundations before backfilling.
- ☐ Use slab perimeter insulation with an insulating value of R-5; R-11 or greater is better.
- ☐ Use sub-slab insulation with an insulating value of R-5; R-10 is better.
- ☐ Add insulation between floor joists, assure there are no voids or gaps.
- ☐ Use an integral crawl space design, so earth is directly insulated.

2. WALLS

- ☐ Minimize wall area though proper building massing (compact shapes are better).
- ☐ Achieve whole-wall R-values above R-12; the closer to R-25 the better.
- ☐ Add blow-in or sprayed-in insulation to existing walls.
- ☐ Use spray-applied insulation in cavities with many obstacles or irregularities.
- ☐ Use advanced framing techniques.
- ☐ Use alternative wall systems (for better durability and performance): rastra, structurally insulated panels, autoclaved aereated concrete, straw bale, adobe, rammed earth, poured earth, cob, etc.

3. WINDOWS and DOORS

- ☐ Glazing should be of double panes
- ☐ 7-12% of floor area in glazing for south exposure
- ☐ About 18 inches of shading over each south facing window.
- ☐ East and north glazing of no more than 4% of floor area
- ☐ West glazing of no more than 2% of floor area.
- ☐ Use windows with a whole-unit U-factor less than 0.56 (R-1.8); under 0.32 (R-3.0) is better; or use super-widows with a whole-unit U-factor less than 0.25 (greater than 4-4).
- ☐ Avoid divided-lite windows (many small panes).
- ☐ Use exterior doors with R-values of R-4 or greater.

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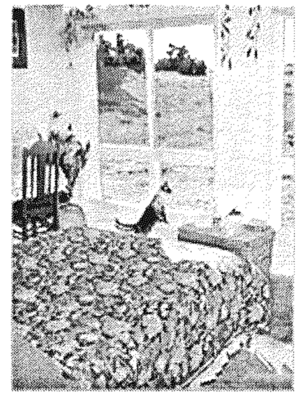
Passive Solar Window Design

Windows are an important element in passive solar home designs, which can reduce heating, cooling, and lighting needs in a house.



Properly designed, energy efficient windows represent a cost-effective way to use solar energy for heating.
Photo credit: Dwight Stone.

Passive solar design strategies vary by building location and regional climate. The basic techniques involving windows remain the same—select, orient, and size glass to control solar heat gain along with different glazings usually selected for different sides of the house (exposures or orientations). For most U.S. climates, you want to maximize solar heat gain in winter and minimize it in summer.

Heating-Dominated Climates

In heating-dominated climates, major glazing areas should generally face south to collect solar heat during the winter when the sun is low in the sky. In the summer, when the sun is high overhead, overhangs or other shading devices (e.g., awnings) prevent excessive heat gain.

To be effective, south-facing windows usually must have a solar heat gain coefficient (SHGC) of greater than 0.6 to maximize solar heat gain during the winter, a U-factor of 0.35 or less to reduce conductive heat transfer, and a high visible transmittance (VT) for good visible light transfer.

Windows on east-, west-, and north-facing walls are reduced in heating climates, while still allowing for adequate daylight. East- and west-facing windows are limited because it is difficult to effectively control the heat and penetrating rays of the sun when it is low in the sky. These windows should have a low SHGC and/or be shaded. North-facing windows collect little solar heat, so they are used just to provide useful lighting.

Low-emissivity window glazing can help control solar heat gain and loss in heating climates.

Cooling-Dominated Climates

In cooling climates, particularly effective strategies include preferential use of north-facing windows and generously shaded south-facing windows. Windows with low SHGCs are more effective at reducing cooling loads. The following types of glazing help reduce solar heat gain, lowering a window's SHGC:

- Low-E
- Tinted
- Reflective
- Spectrally Selective.

Most of these glazing types, except for spectrally selective, also help lower a window's VT.

Related information

Passive Solar Home Design

Learn More

Codes & Standards

- Solar Heat Gain Coefficient FAQs
  DOE Building Energy Codes Program

Evaluation Tools

- Window Heat Gain
  DOE Building Energy Software Tools Directory
- FenSpec
  DOE Building Energy Software Tools Directory
- Window
  DOE Building Energy Software Tools Directory
- SOLAR-2
  DOE Building Energy Software Tools Directory
- Solar Radiation Data Manual for Buildings
  Renewable Resource Data Center
- RESFEN 3.1
  Lawrence Berkeley National Laboratory

Related Links

- Climate Zone Recommendations
  Efficient Windows Collaborative
- Passive Solar Design
  A Sourcebook for Green and Sustainable Building

Reading List

- *Passive Solar Design* (PDF 233 KB). (December 2000). DOE/GO102000-0790. Work Performed by the NAHB Research Center, Southface Energy Institute, and Oak Ridge National Laboratory. Washington, D.C.: U.S. Department of Energy.
- *The Facts about Solar Heat Gain and Windows* (PDF 187 KB). (January 2005). National Fenestration Rating Council. 2 pp.

U.S. Department of Energy - Energy Efficiency and Renewable Energy

A Consumer's Guide to Energy Efficiency and Renewable Energy

Low-emissivity Window Glazing or Glass

Low-emissivity (Low-E) coatings on glazing or glass control heat transfer through windows with insulated glazing. Windows manufactured with Low-E coatings typically cost about 10%–15% more than regular windows, but they reduce energy loss by as much as 30%–50%.

A Low-E coating is a microscopically thin, virtually invisible, metal or metallic oxide layer deposited directly on the surface of one or more of the panes of glass. The Low-E coating reduces the infrared radiation from a warm pane of glass to a cooler pane, thereby lowering the U-factor of the window. Different types of Low-E coatings have been designed to allow for high solar gain, moderate solar gain, or low solar gain. A Low-E coating can also reduce a window's visible transmittance unless you use one that's spectrally selective.

To keep the sun's heat out of the house (for hot climates, east and west-facing windows, and unshaded south-facing windows), the Low-E coating should be applied to the outside pane of glass. If the windows are designed to provide heat energy in the winter and keep heat inside the house (typical of cold climates), the Low-E coating should be applied to the inside pane of glass.

Window manufacturers apply Low-E coatings in either soft or hard coats. Soft Low-E coatings degrade when exposed to air and moisture, are easily damaged, and have a limited shelf life. Therefore, manufacturers carefully apply them in insulated multiple-pane windows. Hard Low-E coatings, on the other hand, are more durable and can be used in add-on (retrofit) applications. The energy performance of hard-coat, Low-E films is slightly poorer than that of soft-coat films.

Although Low-E coatings are usually applied during manufacturing, some are available for do-it-yourselfers. These films are inexpensive compared to total window replacements, last 10–15 years without peeling, save energy, reduce fabric fading, and increase comfort.

Learn More

Product Information

- Residential Windows, Doors, and Skylights
  ENERGY STAR
- Product Ratings
  National Fenestration Rating Council
- Window Selection Tool
  Efficient Windows Collaborative

4. ROOFS

- ☐ Achieve whole-roof R-value of 12 or greater; closer to R-55 or greater is better.
- ☐ Design roof system with consistent thermal integrity.
- ☐ Design roof system with raised rafters or trusses to avoid cold corners.
- ☐ Use alternative roofing: durable steel, tile, slate, etc.
- ☐ Use alternative roof structure such as structurally insulated panels.
- ☐ Use integral attic design with all insulation at the roof plane.

5. INFILTRATION

Seal buildings against air infiltration, but provide adequate air exchange.

- Tight construction of the entire building envelope helps ensure good indoor air quality by avoiding dirt, dust, and other impurities getting into the building.

- ☐ Use continuous air barriers.
- ☐ Keep all mechanical, electrical, and plumbing systems within the air and vapor barriers.
- ☐ Minimize plumbing, electrical, and other penetrations through the building envelope.
- ☐ Seal all penetrations through the building envelope.
- ☐ Seal all joints with caulks or gaskets.
- ☐ Use appropriate caulks and sealants for different applications.
- ☐ Use air lock entries.
- ☐ Use widows with infiltration rates no greater than 0.06 cfm/ft; 0.06 cfm/ft is better.
- ☐ Minimize pressure difference between the building and the outside - by balancing rooms.
- ☐ Perform blower door testing.
- ☐ Pressure-test the building envelope using the mechanical system.
- ☐ Perform duct leakage testing.

HEATING, COOLING, and VENTILATION

Provide efficient, properly sized, environmentally responsible systems.

- Take into consideration whether the building is solar designed, as such buildings require smaller main or back-up heating, cooling and ventilation systems.

1. HEATING

- ☐ Use siting and topography to shield the building from winter winds.
- ☐ Site the building on a south-facing slope.
- ☐ Site the building for southern exposure.
- ☐ Locate spaces used in the morning on the east side of the building.
- ☐ Locate spaces used in the afternoon on the west side of the building.
- ☐ Do not shade the south side of the building with trees.
- ☐ Reduce winter wind speeds with windbreaks (trees, bushes, walls, etc.).
- ☐ Use direct-gain passive solar heating with mass-walls.
- ☐ Use sunspace passive solar heating (with attached solar space).
- ☐ Use active solar heating, with collectors and heat exchangers.
- ☐ Use hot water (under floor) heat distribution.
- ☐ Use modular boilers that can be staged to meet varying loads.
- ☐ Size heating systems appropriately (using good insulation to reduce HVAC size).
- ☐ Use furnaces with variable-speed and modulating blowers and burners.

- ☐ Keep heating equipment in conditioned space.
- ☐ Design heating distribution systems for a large temperature drop.
- ☐ Preheat intake combustion air with exhaust products.
- ☐ Retrofit existing heating system with heat recovery ventilation unit (HRV).
- ☐ Replace existing heating system with higher efficiency system (90%+ efficiency gas).
- ☐ Locate heating equipment in an accessible place for maintenance and service.
- ☐ Use high efficiency wood stoves - use half the wood and save labor and trips.
- ☐ If using coal make sure stove is built for efficient use of coal.
- ☐ Use wood pellet stoves for highest efficiency and lowest emissions.
- ☐ Install good damper and airtight doors on fireplaces.

2. COOLING

- ☐ Use siting and topography to enhance summer breezes.
- ☐ Orient the building properly for right amount of heat gain according to climate.
- ☐ Use heliodin studies (with a model) to optimize shading strategies.
- ☐ Select light colored exterior walls and roofs.
- ☐ Use radiant barriers in roofs.
- ☐ Provide operable windows for natural ventilation and ceiling (paddle) fans to increase air flow in buildings. This can permit down-sizing of mechanical cooling equipment, reducing equipment costs.
- ☐ Strategically place windows to purge heat buildup during the day and evening by creating cross-ventilation through the building (use venturi and heat stack chimney effects).
- ☐ Provide high-low openings to remove unwanted heat by stack ventilation.
- ☐ Minimize number and size of east and west windows.
- ☐ Use south windows with low SHGC, except when winter solar gain is desired.
- ☐ Use east and west widows with low solar heat gain coefficients (SHGC).
- ☐ Shade east and west windows with trees and shrubs.
- ☐ Locate garages and porches on the east and west sides of the building.
- ☐ Shade south facing windows with properly sized overhangs (brows).
- ☐ Shade south facing windows with exterior louvers, awnings, or trellises.
- ☐ Shade south facing windows with trees and shrubs (deciduous for winter heating).
- ☐ Use reflective shades or blinds.
- ☐ Minimize the number of skylights (use light tubes).
- ☐ Shade building walls and roofs with trees (deciduous for winter heating).
- ☐ Provide an open floor plan and openings located to catch prevailing breezes.
- ☐ Make a high internal mass building.
- ☐ Use whole-house fan for night cooling.
- ☐ Use window fans for night coolilng.
- ☐ Use ceiling fans to improve comfort at higher temperatures.
- ☐ Delay heat generating activities until evening or night.
- ☐ Reduce internal heat gains by improving lighting and appliance efficiency.
- ☐ Reduce internal sources of humidity.
- ☐ Size cooling equipment appropriately.
- ☐ Use accurate simulation tools to design the cooling system.
- ☐ Use evaporative cooling.
- ☐ Use night sky radiative cooling.
- ☐ Use chillers with high-efficiency screw compressors or scroll compressors.

- ☐ Use centrifugal chillers.
- ☐ Use AC systems with a high efficiency rating.
- ☐ Specify Energy Star-rated room air conditioners.
- ☐ Use high-efficiency electric air-to-air heat pumps.
- ☐ Specify low-pressure-drop cooling coils.
- ☐ Use low-temperature cooling air distribution.
- ☐ Use an air-side economizer.
- ☐ Design chilled-water loops for a large temperature rise.
- ☐ Use efficient cooling towers (with wind scoops).
- ☐ Use air-cooled mechanical cooling equipment (for smaller buildings/cooler climes).
- ☐ Use water-cooled mechanical cooling equipment.
- ☐ Use waterside economizers in chiller-based cooling systems.
- ☐ Use evaporative condensers.
- ☐ Site condensing units out of the sun and in areas with adequate ventilation.
- ☐ Use active solar absorption cooling.
- ☐ Locate cooling systems in areas accessible for maintenance and service.
- ☐ Commission the HVAC system (test though entire operating scenarios).

3. DISTRIBUTION, VENTILATION, CONTROLS

- ☐ Consider using an access floor system.
- ☐ Seal ducts with mastic.
- ☐ Size pipes and ducts larger for low-pressure drop.
- ☐ Minimize bends in duct work.
- ☐ Specify turning vanes or large radius bends in duct work.
- ☐ Keep duct work out of unconditioned space.
- ☐ Keep ducts away from exterior walls to improve energy performance and save money-because less ducting will be required (good energy performance of the building is required).
- ☐ Insulate duct work located in unconditioned space.
- ☐ Use jump-ducts between rooms to equalize pressure between all rooms in building.
- ☐ Use variable frequency drives for fans.
- ☐ Increase area of filters/specify low-face-velocity filters.
- ☐ Use high-efficiency pumps and motors.
- ☐ Use high-efficiency fans and motors.
- ☐ Size fans and pumps properly to meet the loads.
- ☐ Draw supply air from favorable microclimates around the building.
- ☐ Use heat-recovery ventilation system.
- ☐ Use enthalpic (heat + moisture) heat-recovery ventilation system.
- ☐ Use air distribution strategies with high-ventilation effectiveness, to get air to people.
- ☐ Use displacement ventilation, to put air low at user height levels.
- ☐ Use demand-controlled ventilation.
- ☐ Use variable-speed fan if furnace fan is used for ventilation.
- ☐ Provide sufficient sensors and control logic.
- ☐ Use thermostats with night setback.
- ☐ Use seven-day programmable thermostats.
- ☐ Locate thermostats in central area out of direct sun.
- ☐ Use direct digital control (DDC) systems.
- ☐ Use occupancy-based conditioning controls.

□ Use variable-volume air distribution systems.
□ Zone the building for modular HVAC control.
□ Create zones that unite spaces with similar thermal requirements.
□ Locate spaces used after normal occupancy hours near one another.
□ Provide separate HVAC systems for spaces with distinct heating and cooling loads.

LIGHTING

Optimize daylighting in buildings, the augment with best lighting practices.
□ Orient the floor plan on an east-west axis for best daylighting.
□ Locate frequently used areas on the south side of the building.
□ Design an open floor plan to allow exterior daylighting to penetrate the interior.
□ Use south-facing windows for daylighting.
□ Do not shade the south side of the building with trees.
□ Use and atrium for daylighting.
□ Locate floor openings under top-lighting penetration.
□ Use low partitions near the exterior glazing to promote daylight penetration.
□ Use large exterior windows and high ceilings to increase daylighting.
□ Use building elements to redirect daylight and control glare (e.g. light shelves).
□ Use large interior windows to increase daylight penetration.
□ Use north/south roof monitors and/or celestories for daylighting.
□ Use skylights for daylighting.
□ Use light tubes and/or active tracking skylights for daylighting.
□ Minimize ambient lighting (general lighting is ceiling fixtures) by provide task lighting; this will save money of fixtures and save energy for lighting and cooling.
□ Install compact fluorescent light (CFL) bulbs/ replace most incandescent lights with CFLs.
□ Eliminate or reduce outdoor lighting (including through use of motion-sensor controls) to save energy and reduce light pollution, while saving money.
□ Design outdoor spaces with night-safety in mind, thus reducing lighting need.
□ Use light colors on surfaces and finishes.
□ Use the lowest ceiling height that permits proper use of space.
□ Use reflective suspended ceilings.
□ Design for no more than 1.0 watts/square foot.
□ Use light levels appropriate for different tasks.
□ Specify Energy Star-rated lighting equipment.
□ Use halogen infrared reflector lamps for display or track lighting where necessary.
□ Use LED or other super-efficient exit signs.
□ Use T-5 high-bay fixtures in high-ceiling areas.
□ Use high-efficacy T8 fluorescent lamps
□ Use metal halide lamps for area or down-lighting.
□ Use high-pressure sodium lamps for area lighting when color rendition not important.
□ Use fiber optics for display lighting.
□ Use solar-powered pathway lights, direct light downward.
□ Use high-efficiency electronic fluorescent lamp ballasts.
□ Use automatic-dimming electronic fluorescent lamp ballasts.
□ Use dimming switches and lamps with 1,2,3 lamp operation

APPLIANCES and EQUIPMENT

☐ Use energy efficient motors of correct size
☐ Use Energy Star copiers and fax machines
☐ Use Energy Star computer equipment
☐ Use laptop computers
☐ Turn off computers and equipment when not in actual use.
☐ Use Energy Star-rated refrigerators and freezers; don't set temperatures too low.
☐ Locate refrigerators and freezers away from heat sources and direct sunlight.
☐ Use high efficiency clothes washers.
☐ Use Energy Star dish washers that have energy saving features.
☐ Use microwave and convection ovens.

WATER HEATING and SOLAR HOT WATER

☐ Use Energy Star water heaters with highest ratings.
☐ Use heat-pump water heaters.
☐ Use on demand water heaters.
☐ Use a combined furnace/water heater to heat water.
☐ Use an insulating water heater blanket.
☐ Minimize the length of hot water piping.
☐ Insulate hot water piping.
☐ Use differing water temperatures for general and sanitary uses.
☐ Insulate hot and cold water pipes.
☐ Install on-demand hot water circulation pump.
☐ Convert to tankless water heaters

Solar water heaters may be a good investment for homes and businesses. Although the initial cost is higher than conventional hot water heaters, the fuel (sunshine) is free, and they produce no toxic emissions. These systems use the sun to heat either water or a heat-transfer fluid, such as water-glycol antifreeze mixture, in collectors generally mounted on the roof. There are three kinds of collectors: Flat-plate collectors, Evacuated-tube collectors, and concentrating collectors. Insulated tanks store the hot water and some use pumps to circulate the water.
☐ Investigate the solar hot water information at www.azsolarcenter.com.

PART 3. LOCAL ENERGY GENERATION

Local energy generation may include the use of photocells (solar photovoltaics), wind turbines, solar thermal water heating, geothermal energy use, and power generation from biomass burning or fuel cells.

Why might communities want to get into local energy generation? Four reasons are often given:

1) The US has an energy crises so must find substitutes for oil. We passed the peak of oil and gas production many years ago, yet demand keeps rising, and there are few substitutes for many uses of gas and oil.

2) There is a national security crisis from over half of US oil and gas coming from abroad. We depend on free trade to get the oil and gas we need, yet politics, terrorism and war may obstruct trade and thus interrupt supplies of gasoline and gas to cars, homes and other buildings. Many people would die in areas of the US if natural gas supplies were interrupted and cars and trucks could not run for extended periods.

3) There is a global climate change crisis from greenhouse gasses released from our massive burning of fossil fuels. Wind, sun, and geothermal are clean and don't produce air pollution.

4) Currently energy is supplied by very large and remote corporations who pass rising costs onto customers. Communities and individuals want energy independence from rising energy costs, from outside "brokers" who control supply and costs, from these off-tribal power plants who will face increasing fuel and transmission costs.

Since the sun produced all the fossil fuels we use (coal, oil, gasoline, natural gas, coal), why not go to the source, the sun, and collect renewable energy directly from solar rays, wind and wood? Solar, wind, and geothermal energy generation boosts energy security, reduces pollution, creates high-tech jobs, conserves scarce water resources, and can revitalize rural communities.

- Western governors want 30,000 megawatts of clean energy by 2015; this would power 7.5 million homes.
- The state of Arizona renewable energy standards state that the percentage of renewable energy must be: 2.5% by 2010, 5% by 2015, 10% by 2020, and 15% by 2025.

ENERGY EFFICIENCY MAXIMIZATION

Except were tribes are considering on-site power generation as a commercial venture, they should first maximize energy efficiency before making final decisions about on-site power generation. The life-cylce cost of reducing energy needs often far outweigh the life-cycle cost of generation power.

- For example, it is much cheaper to spend scarce funds on compact fluorescent lights for your building, rather than buy photovoltaic panels or wind turbine capacity to run less efficient standard light bulbs.

• Example two: if you heat your home with wood, the most cost effective way to save energy is to get a high efficiency stove and build or re-model your home to be twice as energy efficient for heating. Then you may only need half the amount of wood each winter, saving a great deal of time and money from half the cutting and half the transportation costs. Switching to electric heat and buying wind turban capacity or photovoltaic panels is cost-prohibitive.

PHOTOVOLTAICS

Solar photovoltaic (PV) cells are thin film semiconductors produced in layers from silicon and other conductive materials. When the sun strikes the PV cell, chemical reactions release electrons, generating electric current. Each PV cell module contains many cells and produces a small current that can power individual homes and businesses, can connect to the mainstream power grid, or can be stored in battery arrays.

• PV panels can be firmly to a buildings roof. PV panels can be installed separately from the building employing a tracking devise to follow the sun, thus producing 30% more power.

• PV cells can also be integrated into window panes and roof tiles.

- Design for roof surfaces on buildings to accommodate future PV installations.

• Zero Energy Homes are connected to the regular power grid and can sell extra power back to the power company. During times of peak demand, a Zero Energy Home generates more power than it uses, thereby reducing power demand on the utility provider so needed power goes to other homes. So it will be the law for all power companies to buy back power for the same rate that they sell it for.

- Check with your local power company on their policies and incentive programs for PV systems.

• Solar farms are locations where hundreds of solar PV panels are clustered to generate electricity for sale for local use or regional power grids.

• The price for solar panels has been coming down; the price for a watt of solar power, adjusted for inflation, went from $21.83 in 1980 to $2.70 in 2005. Within five years the price of solar power is predicted to rival the conventional price of power.

Hopi Solar Electric Enterprise - Native Sun

The Hopi Solar Electric/Native Sun was established in 1985 by the Hopi Foundation to assist Native American families living in isolated locations who do not have access to electricity. Typical small, off-grid systems are one to two kW systems. They are less expensive than gasoline generators, easier to maintain, cleaner, and quieter. These systems are used for basic electrical conveniences, such as lighting, refrigeration, water pumping and other needs of everyday life. Often, the panels can be installed to provide outdoor shade while working to provide needed electricity inside. Currently, Native Sun serves the Hopi community and the Navajo Nation, as well as local non-Indian landowners. Native Sun has installed more than 300 solar electric systems. Native Sun has a revolving loan program to assist homeowners in purchasing systems, which usually range from two to eight panels (100-600 watts). Although originally established with foundation grants, the program is moving towards economic self-sufficiency.

Contact: The Hopi Foundation
P.O.Box 705 Hotevilla, Az 86030 www.nativesun.biz

Photovoltaic Systems (Modular)

Photovoltaic systems generate power from the sun's energy and are a leading form of renewable energy. They are most appropriate for buildings that use advanced energy efficiency measures.

Technology Description

In a photovoltaic system, solar energy is absorbed in a special silicon cell that creates DC electric current, which is then passed through an inverter to provide conventional AC power. Photovoltaic systems are also available that have built-in inverters, making them easy to connect with the utility grid. In most areas, power can be sold directly to the electric utility by feeding excess power onto the grid.

Photovoltaic systems fall into two broad categories:

- PV panels or arrays that serve as add-on energy production systems, and
- Building Integrated Photovoltaic (BIPV) systems in which the solar collection surface is integrated into the building envelope.

This Technology Profile focuses on modular photovoltaic systems. BIPV is discussed in detail in a separate Technology Brief.

Design Considerations

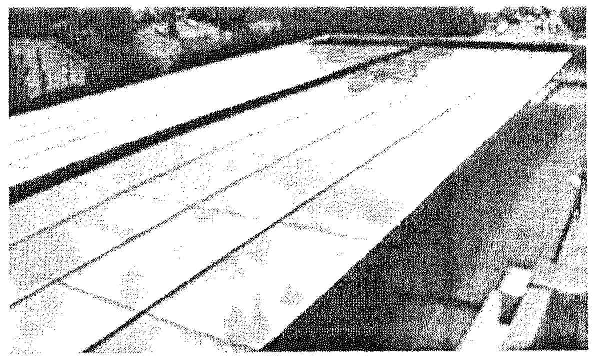
To maximize the annual energy output, photovoltaic panels are oriented to the south and tilted typically from 10 to 40 degrees up from the horizontal in most North American sites. The optimal tilt for collecting solar energy depends on the latitude of the system, the proposed use of the system and the local seasonal cloud cover profile. The primary design considerations include supporting the weight of the photovoltaic panels and securing the panels against wind and seismic movement.

Potential Energy Generation

Depending on the type of module, photovoltaic panels can generate approximately 5 to 10 watts of power per square foot of collector area in full sunlight. So a collector area of 100 to 200 square feet typically is needed per kilowatt of capacity. The annual power output varies with the latitude and climate and ranges from 1,400 to 2,000 kilowatt-hours per kW of installed capacity.

Estimated Benefits

A 10-kW photovoltaic system commonly generates between 14,000 and 20,000 kilowatt-hours in a year, depending on the latitude and climate. At $0.05 per kilowatt-hour, such a system would produce estimated annual power valued at between $700 and $1,000. At $0.10 per kilowatt-hour, a 10-kW system would produce estimated annual power valued at between $1,400 and $2,000.



Photovoltaic systems offer other benefits in addition to the value of the power produced. Photovoltaic modules can be used with batteries to provide building power during outages. In some installations, photovoltaic panels can serve as shading devices on a building's exterior to help reduce solar gain and glare. Photovoltaic systems also offer a visible sign of a commitment to renewable energy and green building. Depending on sources of the local electricity supply, photovoltaic power systems can provide the environmental benefit of offsetting 1 to 2 lbs. of CO_2 emissions for each kilowatt-hour they generate (compared to fossil-fueled electric plants). And they can provide educational benefits at schools, museums, libraries and other locations.

Estimated Costs

Photovoltaic modules cost about $7 to $10 per watt installed, or $7,000 to $10,000 per kW. Therefore, a 10-kW system would cost between $70,000 and $100,000 prior to any tax credits, utility incentives, rebates or other savings (based on 2001 costs).

Financing Options

Financing may be available directly from manufacturers or from third-party equipment leasing or energy services companies. Federal and state tax credits, utility rebates and accelerated depreciation benefits may be available depending on the system and its location.

WIND ENERGY

Energy from the wind can be converted to electricity effectively with horizontal wind turbines.
- President Bush wants 20% of US energy coming from wind.

1. HOME SCALE WIND GENERATION

Small wind turbines (usually producing less than 10 kilowatts of electricity) can be used to generate electricity in homes and small businesses. A typical 10-kilowatt home system may be about 100 feet tall with a blade diameter of about 20-25 feet and may cost $25,000 to install. Depending on the amount of wind available, it will produce between 10,000 and 18,000 kilowatt hours (kWh) per year. Home sitting on a one acre parcel could probably accommodate such a turbine, depending on local zoning regulations. The smaller turbines today are fairly efficient, producing electricity in winds as low as 7 to 10 miles per hour. They are also fairly quiet and can be designed to generate power at the same voltage as homes use. To be a candidate for a wind system, your site must have adequate winds.
Located in Flagstaff, AZ, Southwest Windpower is the world leader in small wind turbines:

> FLAGSTAFF, AZ., June 27 – A new small residential wind generator from Southwest Windpower will give homeowners a new weapon in the fight against rising electricity costs. Skystream 3.7™ is the first fully integrated wind generator designed specifically for the grid-connected residential market.
>
> A combination of new technologies, developed in collaboration with the U.S. Department of Energy's National Renewable Energy Laboratory, resulted in a product that quietly produces electricity for a fraction of the cost of current technologies. Skystream's low cost and low profile provides homeowners an affordable energy supplement that's appropriate for installation in many residential areas around the country. With no batteries, Skystream 3.7 connects directly to the home to supply power. When the wind is not blowing, the home is powered by the electric utility. Depending on the local utility, excess electricity can be sold back to the utility or used at a later date.
>
> "Skystream will change the way many Americans power their homes and take control of their energy costs," said Andrew Kruse, co-founder of Southwest Windpower. "Wind energy for the individual homeowner is finally main-stream."
>
> With a typical cost of $8,000 to $10,000 to purchase and install, Skystream 3.7 can pay for itself in 5 to 12 years. This payback period will vary and can be much quicker in states with investment rebates. It's anticipated that Skystream 3.7 will save the average homeowner $500 to $800 per year, based on 4,800 to 6,600 kWh produced per year and a $0.12/kWh cost of electricity. This output would provide 40 to 90 percent of an average home's energy needs. In states like Hawaii, where the cost of energy and wind speeds are both high, Skystream 3.7 can pay for itself in less than 4 years.

- ☐ Consider using a small wind turbine system to generate electricity for a building.
- ☐ Consider using a small wind turbine system to pump water.

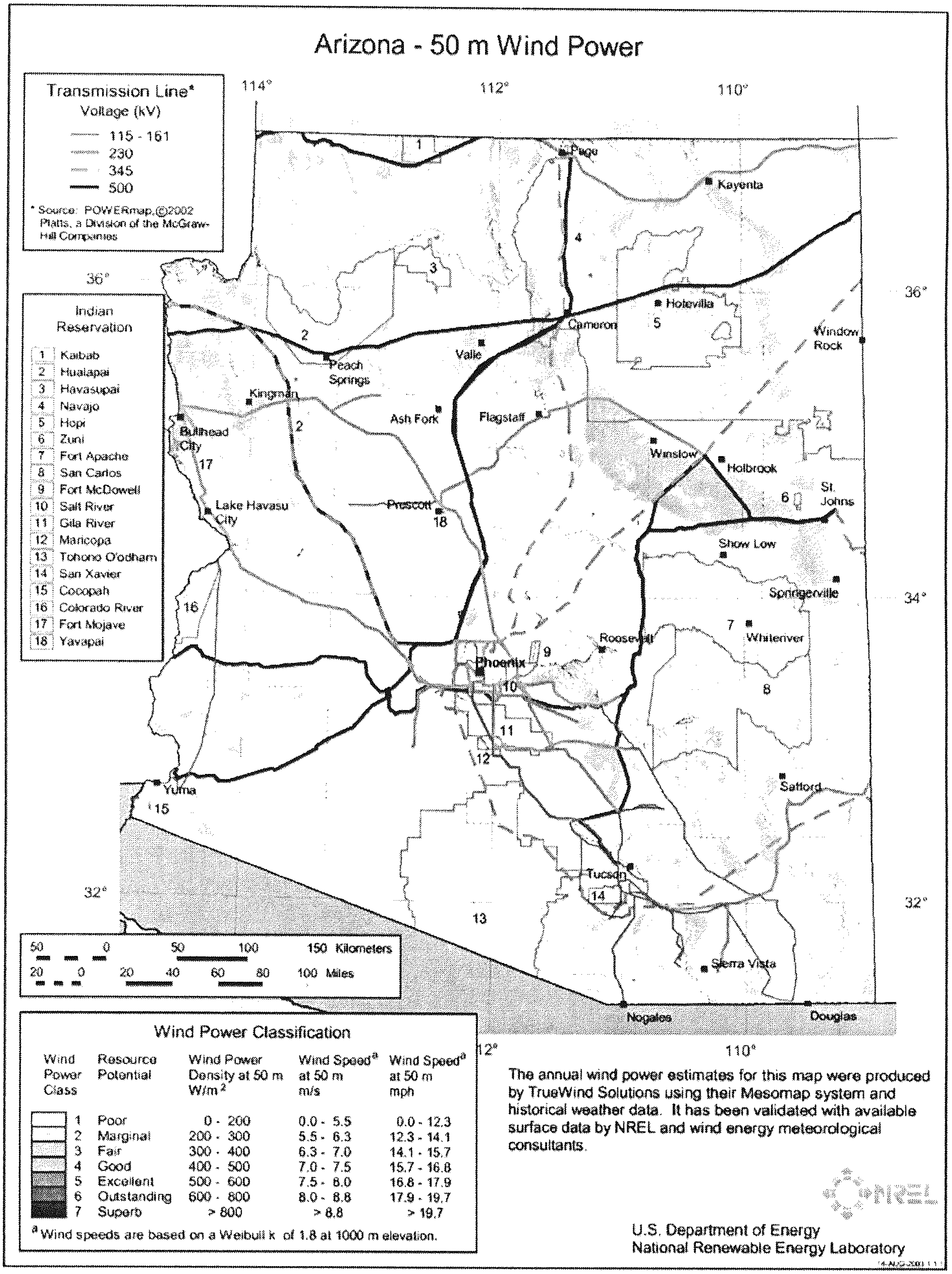
2. LARGE SCALE COMMERCIAL WIND GENERATION

The new state-of-the-art wind farms use huge 1.5 to 2.0 megawatt turbines that are almost 400 feet in total height - the size of a 747 jumbo jet airplane twirling vertically. The three long blades move slowly, taking several seconds per revolution, and produce little noise. A 60 megawatt farm may have 40 turbines over an eight square mile area, producing enough energy for 15,000 homes (the size of the city of Flagstaff). The land could still be used for livestock grazing, farming, or other open-space uses while generating lease income for the landowners.

- Only very large investment companies can install and run such wind farms do to the high cost, technology, regulation, and financial risk (turbans can cost $2 million each).
- There is a complex process of deciding where wind farms should be located. The energy investment companies first look and wind maps (see below) of the state to decide which areas have proven sustainable wind supplies.
- These location much also be near large power lines run by existing power companies like SRP and APS. The companies will then put up test turbines and monitor wind conditions for over a year before deciding if they want to make contracts with landowners.
- For more information on wind energy see American Wind Energy Association (www.awea.org) US Department of Energy, Wind Powering America Program, (www.eere.energy.gov/windandhydro/windpoweringamerica), and (www.foresightwind.com).

THE INDIAN ENERGY RESOURCE DEVELOPMENT PROGRAM

Several renewable energy projects have received financial assistance from the Department o Energy pursuant to the Indian Energy Resource Development Program authorized by Title XXVI of the Energy Policy Act of 1992. Since 1994 more than 56 projects have been funded at a level of more than $31 million. In 2002, the program funded $2.5 million in projects. These included a photo-voltaic water pumping system on the Ute Mountain Reservation in Colorado, utility-scale wind turbines on the Blackfeet Reservation in Montana, and hydroelectric projects sponsored by Agdaagux Tribe and Native Village of Chignik Lagoon in Alaska. In addition, this DOE program aided some feasibility studies and resource assessments, including biomass cogeneration sponsored by the White Mountain Apache Tribe in Arizona and the Keweenaw Bay Indian Community in Michigan.
Source: DOE and "Renewable Energy in Indian Country," David Suage.
http://solstice.crest.org/repp/pubs/articles/issuebr10/ussuebr10.htm.



Arizona - 50 m Wind Power
Transmission Line*
Voltage (kV)
115 - 161
230
345
500
* Source: POWERmap, ©2002 Platts, a Division of the McGraw-Hill Companies
Indian Reservation
1 Kaibab
2 Hualapai
3 Havasupai
4 Navajo
5 Hopi
6 Zuni
7 Fort Apache
8 San Carlos
9 Fort McDowell
10 Salt River
11 Gila River
12 Maricopa
13 Tohono O'odham
14 San Xavier
15 Cocopah
16 Colorado River
17 Fort Mojave
18 Yavapai
114°
112°
110°
36°
34°
32°
Page
Kayenta
Hotevilla
Cameron
Window Rock
Peach Springs
Valle
Kingman
Ash Fork
Flagstaff
Bullhead City
Winslow
Holbrook
St. Johns
Lake Havasu City
Prescott
Show Low
Springerville
Whiteriver
Roosevelt
Phoenix
Safford
Yuma
Tucson
Sierra Vista
Nogales
Douglas
50 0 50 100 150 Kilometers
20 0 20 40 60 80 100 Miles
Wind Power Classification
Wind Power Class | Resource Potential | Wind Power Density at 50 m W/m² | Wind Speed[a] at 50 m m/s | Wind Speed[a] at 50 m mph
1 Poor 0 - 200 0.0 - 5.5 0.0 - 12.3
2 Marginal 200 - 300 5.5 - 6.3 12.3 - 14.1
3 Fair 300 - 400 6.3 - 7.0 14.1 - 15.7
4 Good 400 - 500 7.0 - 7.5 15.7 - 16.8
5 Excellent 500 - 600 7.5 - 8.0 16.8 - 17.9
6 Outstanding 600 - 800 8.0 - 8.8 17.9 - 19.7
7 Superb > 800 > 8.8 > 19.7
[a] Wind speeds are based on a Weibull k of 1.8 at 1000 m elevation.
The annual wind power estimates for this map were produced by TrueWind Solutions using their Mesomap system and historical weather data. It has been validated with available surface data by NREL and wind energy meteorological consultants.
U.S. Department of Energy
National Renewable Energy Laboratory

GROUND COUPLED ENERGY SYSTEMS

Due the heat difference between the air and inside of the earth, there is potential to extract energy by using earth sheltering, earth tubes, ground-source heat pumps, surface and deep water sinks.

- Earth sheltering involves incorporating much of a building into the earth, by sinking the building into the ground, building it into a hillside, or earth berming outside walls. Since the temperature below ground does not vary much the earth moderates temperature swings within the building.
  - ☐ Consider how earth coupling may work for you building in your climate. Remember that the earth temperature may be too cool in the winter so it may put an uncontrollable heat load on your heating system.
- Earth tubes are a means of keeping your building totally above ground, and using large diameter pipes to circulate air to preheat or pre-cool ventilation air going into the building, thus cutting energy costs for heating and cooling, and allowing for a smaller HVAC system.
- Ground-source heat pumps function similar to regular air heat pumps, except tubes sunk into below-ground chambers exchange heat with the earth instead of outside air.
- Surface-water heat pumps function similar to an air or ground-source heat pump, except underwater pipes exchange heat for direct or mechanical cooling and heating.
- Deep well water heat pumps function similar to an air, ground or pond-source heat pump, except pipes sunk into the water table exchange heat for direct or mechanical cooling and heating.
  - ☐ Assess unique characteristics of your building site to see if the above listed ground-coupled energy systems may be cost-effective for your site.

BIOMASS ENERGY

Some areas of Arizona produce an over-abundance of woody materials that may be burned for heat energy to heat buildings or generate electricity.

- The vast ponderosa pine forests in central Arizona have tree densities over 100 times that of pre-Anglo settlement and need to be thinned to prevent catastrophic fire.
- Large areas of Arizona are covered by increasing numbers of juniper trees that need to be thinned to restore grassland habitat for wildlife, livestock and proper watershed function.
  - ☐ Use an EPA-approved wood stove or fireplace to provide heat to your buildings.
  - ☐ Use a wood-fired masonry heater to provide heat and hot water.
  - ☐ Use and automated wood chip boiler to provide heat and hot water.
- Grant funding may be available in certain areas to help tribal enterprises build small biofuels electric generation stations to burn trees, slash, and agricultural waste to generate electrical power.

WATER PREPAREDNESS

We in Arizona are living in a desert where water is scarce and precious. All our water either comes from wells pumping primarily fossil water or from man-made reservoirs where surface-collected water is pumped and channeled for long distances. Water tables are dropping and surface water is declining due to drought global warming trends. A great deal of energy is used in water transmission, and costs will increase. It is important that we build our infrastructure and buildings to use little water and reuse water on site.

PART 4. WATER EFFICIENCY

It is important to have state-or-the-art professional design for all water systems leading from water sources to buildings, and for use within buildings.

INDOOR WATER USE

- ☐ Install faucet aerator on kitchen faucet.
- ☐ Install lavatory faucets with less than 2 gallon per minute flow.
- ☐ Use automatic faucet controls for lavatories.
- ☐ Install low-flow toilets using under 1.3 gallons per flush.
- ☐ Install toilets with dual-flush tanks.
- ☐ Retrofit existing toilets with flush-volume-reducing devices.
- ☐ Install shower heads using less than 2.2 gallons per minute.
- ☐ Replace older shower heads with low-flow models.
- ☐ Install shut-off buttons or levers on showerheads and faucets.
- ☐ Reduce excessive water delivery pressure.
- ☐ Design floorplan to minimize length of hot water piping.
- ☐ Use a manifold distribution system to shorten length of (smaller) pipe to each fixture.
- ☐ Insulate hot water pipes to reduce water waste during warm-up.
- ☐ Downsize hot-water pipe diameters. This will deliver hot water faster, reduce standby losses from hot water pipes, reduce water waste, and save on pipe materials cost.
- ☐ Specify on-demand hot-water recirculation system to avoid water waste.
- ☐ Install point-of-use hot water heaters to avoid water waste.
- ☐ Avoid garbage disposals as they require significant amounts of water for their operation, and they result in high organic loading of sewage treatment plants or septic tanks. Consider composting.
- ☐ Specify horizontal-axis/ low water using washing machine.
- ☐ Specify low-water-use residential dishwasher.

IRRIGATION and WATER RE-USE

- ☐ Design landscaping with XERISCAPTING -planting for low water use
- ☐ Minimize turf area; convert current turf areas to native ecosystem.

- ☐ Select plants for drought tolerance.
- ☐ Arrange plants in groups according to water needs.
- ☐ Improve soil quality to increase water retention.
- ☐ Use mulch to improve water retention.
- ☐ Use non-plant landscaping.
- ☐ Use appropriate grading to retain irrigation and reduce runoff.
- ☐ Retain water on site in pond for irrigation.
- ☐ Use water-efficient irrigation fixtures.
- ☐ Optimize sprinkler distribution uniformity.
- ☐ Use automatic controls to improve efficiency and effectiveness of irrigation system.
- ☐ Use a moisture meter to control outdoor irrigation.
- ☐ Plumb building to accommodate graywater separation (for now or future).
- ☐ Collect graywater from at least clothes washer, buy also shower and bathroom sink, store it in a cistern for use for landscape plants.
- ☐ Collect rainwater and store in a cistern for domestic uses in the building.
- ☐ Collect and store rainwater for landscape irrigation.
- ☐ Collect and store rainwater for use in swamp coolers and cooling towers.

EDUCATION and INCENTIVES

- ☐ Educate building residents about water conservation features and practices.
- ☐ Educate building management and employees about water conservation.
- ☐ Check rebates on water-conserving fixtures and landscaping.
- ☐ Check rebates on water-conserving appliances.
- ☐ Carry out careful water leakage audit and fix any leaks.

Water Conservation

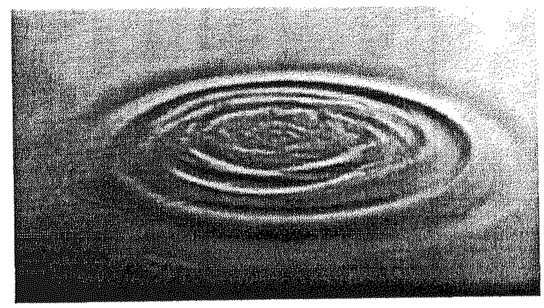
Water consumption in commercial buildings can be reduced as much as 50 percent using a variety of innovative strategies that are integrated into the plumbing and mechanical systems as well as the landscaping design. With water and sewer rates increasing nationwide, such integrated water use management can deliver a favorable economic return while demonstrating responsible use of this precious resource.

Technology Description

Although federal law now requires low-flush (1.6 gallons per flush) fixtures and automatic valves for water closets and public lavatories, the opportunities for water conservation in commercial buildings are still substantial.

Options for further reducing water use and cost include:

- **More efficient fixtures.** Fixtures are now available for water closets that use only 1.2 gallons or less per flush, which is 20 percent less than what is required by the National Energy Policy Act of 1992. Other water-saving options include faucet aerators in sinks and low-flow showerheads in buildings where showers are provided (typically those that have in-house exercise facilities or on-site bicycle parking).
- **Waterless urinals.** Code approval for waterless urinals is increasing, as is their commercial availability. They use a trap liquid with a lower specific gravity than urine, allowing waste to pass through while maintaining a constant trap seal. No water is required and there is no odor. Waterless urinals are becoming common in institutional settings, such as elementary and secondary schools, as well as campus situations, including corporate headquarters. They are easy to maintain, and reduce problems associated with stuck valves and accidental or intentional flooding.
- **Gray water reuse.** Gray water from sinks, kitchens and food service locations can be used for toilet and urinal flushing, cooling tower or boiler makeup water, landscaping and on-site water storage for fire fighting. Such systems require dual piping to route the gray water as well as appropriate valves, filters and signage. Plumbing codes differ widely among jurisdictions as to the acceptability of such approaches.
- **Electric instantaneous hot water heaters.** In areas where electricity is less than $0.06 per kilowatt-hour, "on-demand" electric water heaters placed under lavatories can deliver cost-effective water and energy savings.
- **Rainwater reuse.** In wetter climates, it may be possible to pipe roof drains directly to a storage tank in the building and use that water in the same manner as gray water. Capturing 36 inches of rain per year from a 20,000-square-foot roof would yield 60,000 cubic feet of rainwater, for annual savings of nearly 450,000 gallons.
- **Water-efficient landscaping.** Landscape architects and designers can specify native plantings, which use no water after becoming established, as well as drip irrigation and other low-water-using systems.
- **Cooling Towers.** Submetering can reduce sewer charges by eliminating charges for water lost to evaporation.



Design Considerations

Water conservation is maximized and most cost-effective when it is integrated into the design of a building's plumbing, mechanical, fire-safety and landscaping systems. An effective design strategy is to create multiple uses for each gallon of water: Potable water can be used for drinking, hygiene and health; recaptured water can be used for toilet flushing, boiler and cooling tower makeup as well as landscape irrigation.

For long-term savings, it is beneficial to measure water use as part of on-going building operations and to identify near-term improvements in fixture, circulation and wastewater management design.

Estimated Costs and Benefits

In most communities, water conservation can improve a building's bottom line by reducing water use charges, sewer system charges and "system development" impact use charges.

- Water use charges commonly include fixed charges that may vary with the meter size and consumption charges that are based on monthly or seasonal water use.

HEALTH PREPAREDNESS

Wise selection and placement of materials is important for sustaining health of both humans and ecological systems over the long-term.

PART 5. MATERIALS and RESOURCES

Consider durability and classic design for all projects. A durable, efficient and proud structure will save untold energy and resources over many generations.

RESOURCE EFFICIENCY

- ☐ Assess whether the building is truly needed.
- ☐ Consider remodeling and refurbishing existing structures instead of replacing them…
- ☐ Reconsider whether all space demands in building program are needed.
- ☐ Design and build for phased construction.
- ☐ Provide anchoring in exterior walls for future addition of intermediate stories.
- ☐ Determine whether varying functions can be accomplished in shared spaces.
- ☐ Plan carefully to only use the right amount of materials.
- ☐ Group or stack bathrooms and other water-using spaces.
- ☐ Minimize space devoted exclusively to circulation (foot traffic areas).
- ☐ Consider the use of structural materials that do not require application of finish layers.
- ☐ Consider exposing structural materials as finished surfaces.
- ☐ Provide to contractors (or require from designers) detailed and complete plans and specs.
- ☐ Use an access floor to facilitate reconfiguring of spaces and cabling systems.
- ☐ Use materials and systems with low maintenance requirements.
- ☐ Keep materials dry during construction.
- ☐ Raise wood framing well off of grade.
- ☐ Use landscaping and grading to divert water away from the building.
- ☐ Control rainwater flowing on building surfaces; use roof guttering.
- ☐ Provide a drainage plane in exterior walls to prevent bulk water (rain) penetration.
- ☐ Use salvaged materials (wood, millwork, fixtures, hardware) in new construction. They are often cheaper and save landfill space. Make sure materials are safe and energy efficient.
- ☐ Use structural materials as finish materials. Examples include exposed beams, concrete floor slabs, and tilt-up concrete panels.
- ☐ Use concrete, stone, or brick patios instead of wood decks. This saves redwood and other limited supply trees, and significantly reduces maintenance and replacement costs over the long term.
- ☐ Use locally produced materials (within 500 miles) to reduce transportation energy.
- ☐ Use Environmentally Preferable Products (for energy savings in manufacture, transport, use, maintenance, replacement) in walls, roofing, flooring, fixtures, appliances, adhesives, paints.
- ☐ Use advanced framing techniques or structurally insulated panels that use laminated lumber.

- Quality products and building practices should be used, as quality problems can shorten the life of the assemblies, systems, and/or materials in a home and indeed the home itself.

- Quality products can correlate to improved performance (and improved profits for builders), as measured in decreases in warranty claims for quality-related defects and failures.
  - Build with materials that will properly control water and humidity, so that mold does not take hold and water will not ruin the structure or materials.
  - Keep outside water out of building by assuring all drainage planes are weatherlapped and surfaces have drying potential if wetted. Walls, roofs and floors need air barriers to prevent air infiltration and materials need to prevent interstitial condensation.
  - Use reflective thermal barriers to reduce heat loss from interior spaces.
  - Use non-paper-faced backer board on walls of tub, shower, and other high humidity areas.
  - Use water resistant flooring in kitchens, bathrooms, and three feet from exterior doors. Do not install carpet in these areas.
  - Install drains and single-throw supply valves wherever water heaters or washers are installed over living spaces.
- For materials sourcing look locally for naturally occurring products and rapidly renewable resources.

WASTE MANAGEMENT

- Reuse existing structure.
- Reuse leftover materials or sell them; this also reduces tipping costs and landfills, and saves landfill space.
- Investigate local markets for salvage and recycling.
- Use modular or prefab construction.
- Investigate local infrastructure for recycling.
- Seek a waste hauler who can separate recyclables out of combined waste.
- Designate a recyling coordinator for project.
- Require a waste management plan from the contractor.
- Require weekly job-site recycling training.
- Set up labeled bins to keep recyclable materials separate.
- Require that subcontractors keep their wastes separate.
- Before concrete pours, designate locations or uses for excess concrete.
- Design for disassembly at end of life of the product or assembly.
- Build with reusable modular units.
- Use materials with integral finish.
- Design with refinishable components.
- Facilitate recycling by avoiding materials with toxic components.
- Use biodegradable materials.
- Avoid composite materials to facilitate recyling.
- Select products that manufacturers will take back for recycling (carpet, etc.).
- Consider green leasing of materials and furnishings.
- Specify recycling receptacles that are accessible to the building occupants.
- Design physical in-house recycling system.

Waste Reduction

"Waste reduction" is one of the two approaches used to conserve materials in sustainable buildings. (The other approach, the purchase of reused and recycled products, is discussed in Module 6). Waste reduction can focus on the construction site and can be part of an overall maintenance and operations plan developed along with the construction plan at the beginning of the project. A well-planned approach to Waste reduction will curb construction waste and can facilitate materials reuse and recycling in the building after it is completed. In general, construction and demolition recycling often saves on first costs in areas with established recycling markets.

As with most sustainable building strategies, the net cost of materials conservation strategies will vary depending on the particular circumstances. Rehabilitating buildings, reusing components of existing buildings, or using salvaged building products may result in substantial cost savings, where it is a feasible option.

However, all of the strategies discussed in this module help conserve material resources during the construction of a building and during its future maintenance. But just as importantly, they also have significant environmental benefits involving the reduced use of energy, reductions in air and water pollution during resource extraction and manufacturing, and the safeguarding of scarce natural resources.

WASTE REDUCTION STRATEGIES

- ✓ Prepare and implement a construction waste reduction plan.
- ✓ Rehabilitate existing buildings.
- ✓ Demolition/deconstruction waste management.
- ✓ Design to facilitate recycling and reuse.
- ✓ Specify products that can be repaired or renovated instead of replaced.
- ✓ Specify environmentally preferable products and practices.

Prepare and implement a construction waste reduction plan.

Construction and demolition waste accounts for nearly 12 percent of all waste disposed in California.[1] Most materials generated on construction sites are recyclable or reusable, and State technical assistance and recycling service companies are available to make sure it is recycled. Types of construction waste include concrete, asphalt paving, asphalt roofing, lumber, gypsum board, rock, soil, paint, carpet ends, and fines. Several California cities and counties have adopted ordinances requiring construction site recycling programs.

Some elements of a construction waste reduction plan include:

- Requiring on-site recycling in bid and contract documents for all contractors and subcontractors.
- Holding a pre-construction waste management meeting with all contractors and subcontractors to ensure they understand and agree to abide by all recycling procedures.
- Waste management in all regular meetings during construction.
- Developing clear instructions for all personnel involved at the job site, for example, covering proper handling procedures for each material and contamination concerns.
- A preference for reduced packaging or returnable packaging in supply agreements.
- Minimizing waste generation through efficient framing practices, such as using modular dimensions.
- Assigning designated areas with clear signs for recycling materials.
- Conducting materials separation and processing off-site, reserving the construction site for conventional materials management practices as much as possible.
- Requiring contractors to self-haul materials to reduce the number of trucks visiting the site.

MATERIALS BY Construction Specification Institute DIVISION

1. SITEWORK
- ☐ Enhance existing features in landscaping.
- ☐ Cluster buildings to minimize infrastructure requirements.
- ☐ Minimize width of roadways.
- ☐ Use natural-fiber erosion-control mats.
- ☐ Use retaining wall systems with high levels of recycled content
- ☐ Use porous pavement systems with high levels of recycled content.

2. LANDSCAPING
- ☐ Use imported fill or topsoil from nearest available source.
- ☐ Use organic compost.
- ☐ Specify mulch made from post-consumer waste, or materials removed from site.
- ☐ Use living fencing.
- ☐ Avoid conventional preservative-treated wood.
- ☐ Use recycled-rubber playfield surfaces.

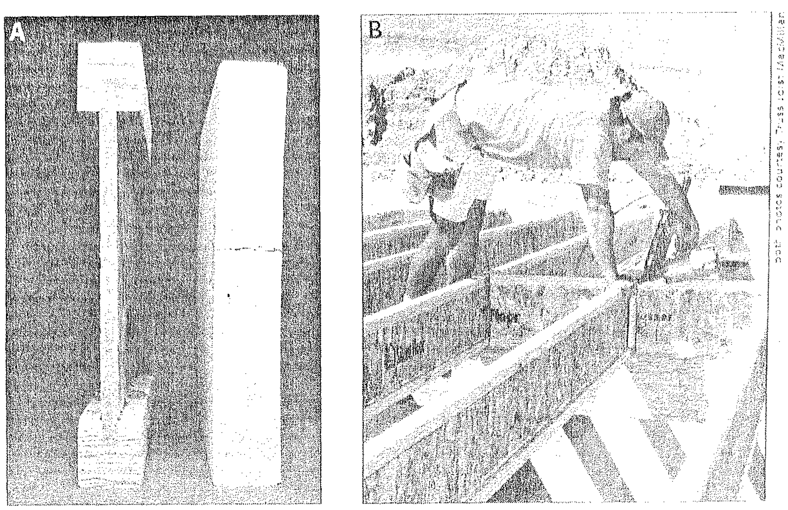
3. CONCRETE
- ☐ Design concrete decks with waffle or other sections that optimize placement of concrete.
- ☐ Use stay-in-place formwork that optimizes placement of concrete.
- ☐ Use reusable concrete forms.
- ☐ Save lumber from forms for reuse in framing and sheathing.
- ☐ Use precast structural concrete components.
- ☐ Replace up to 30% of the cement in concrete with flyash.
- ☐ Use recycled materials as aggregate in the concrete.
- ☐ Specify vegetable oil-based form-release oil.
- ☐ Use rammed-earth walls.
- ☐ Use frost protected shallow foundation.

4. UNIT MASONRY
- ☐ Use salvaged brick.
- ☐ Use clay brick made from contaminated soil or industrial waste products.
- ☐ Use concrete masonry units with flyash replacing a portion of the cement.
- ☐ Use concrete masonry units with recycled or industrial-waste aggregates.
- ☐ Use autoclaved, aerated lightweight concrete.
- ☐ Use adobe walls.

5. METALS
- ☐ Seek alternatives to aluminum/ or specify aluminum products made from high levels of recycled scrap.
- ☐ Use salvaged steel members.
- ☐ Specify heavy steel framing with the highest recycled content.
- ☐ Design to avoid thermal bridging when using light-gauge steel for building shell.
- ☐ Use light gauge steel for interior partitions.

6. WOOD

☐ Use advanced framing (optimum value engineering) to optimize material use.
☐ Specify ceiling heights of 8, 10, or 12 feet to conserve lumber.
☐ Choose naturally rot-resistant wood species for exposed applications.
☐ Use wood treated with less-toxic preservatives than CCA or ACZA.
☐ Avoid endangered wood species and species form sensitive habitats.
☐ Use wood products from independently certified, well-managed forests for rough carpentry.
☐ Use salvaged wood for rough carpentry.
☐ Use engineered wood products for rough carpentry.
☐ Use trusses for roofs and floors.
☐ Use engineered wood products in place of large-dimension timbers.
☐ Use wood products from independently certified, well-managed forests for finish carpentry.
☐ Use salvaged wood for finish carpentry.
☐ Use engineered wood products for finish carpentry.
☐ Avoid wood products made with urea-fomaldehyde binder.
☐ Seal all surfaces of composite woodwork made with urea-formaldahyde-based binders.
☐ Use agricultural-waste-fiber panels for millwork and interior finish.
☐ Use structural premanufactured panels for walls and floors.
☐ Use OSB for subfloor and sheathing.
☐ Use finger-jointed studs.



A. Engineered lumber joist compared to standard joist
B. Installation of engineered lumber joist.

7. INSULATION

☐ Avoid rigid foam insulation made with HCFCs.
☐ Avoid spray-in foam insulation made with HCFCs.
☐ Prefer formaldehyde-free batt insulation.
☐ Protect workers from exposure to glass fibers.
☐ Prefer insulation with high recycled content or of natural fiber (eg. straw).

8. ROOFING and SIDING

- ☐ Use integral roof and wall systems (structurally insulated panels, autoclaved aereated Concrete, etc.).
- ☐ Prefer roofing materials with high levels of recycled content.
- ☐ Prefer the most durable roofing material - i.e. metal or tile roofs may be best in long view.
- ☐ Ensure that flashing details are as durable as the roofing.
- ☐ Prefer recycled roofing materials.
- ☐ Select a roofing system that allows the membrane to be replaced with replacing insulation.
- ☐ Avoid using hardboard siding.
- ☐ Use only hardboard siding with a drained, vented cavity behind.
- ☐ Use fiber-cement siding.
- ☐ Minimize dependence on sealants by good detailing of building skin.

9. WINDOWS

- ☐ Optimize energy performance of glazing systems.
- ☐ Choose frame and sash materials with low thermal conductivity.
- ☐ Select durable window assemblies.
- ☐ Choose frame and sash materials made from recycled materials.
- ☐ Use pan flashing under all windows.

10. DOORS

- ☐ Select insulated outside doors for optimal thermal performance.
- ☐ Choose doors with non-ozone-depleting foam insulation.
- ☐ Use storm doors.

11. WALL AND CEILING FINSHINGS

- ☐ Use wallboard from manufacturers that utilize gypsum form job-site scraps.
- ☐ Use gypsum board made with higher percentages of synthetic gypsum.
- ☐ Specify gypsum wallboard from suppliers that take back scrap for recycling.
- ☐ Use site-mixed rather than premixed joint compounds.

12. FLOORING AND FLOORCOVERINGS

- ☐ Specify wood flooring from independently certified forestry operations.
- ☐ Specify salvaged flooring or flooring from salvaged wood.
- ☐ Specify prefinished wood flooring.
- ☐ Specify rapidly renewable resource flooring such as bamboo and cork.
- ☐ Specify floor tiles with recycled content or low-fired temperature tiles (saltio).
- ☐ Use true linoleum flooring.
- ☐ Use recycled-content rubber flooring.
- ☐ Use recycled-content vinyl flooring.
- ☐ Ensure that concrete slabs are dry before installing flooring.
- ☐ Use solvent-free, water-resistant adhesive recommended by manufacturer.
- ☐ Avoid wall-to-wall carpet.
- ☐ Avoid carpet in areas that are susceptible to moisture intrusion.
- ☐ Avoid adhering carpet directly to concrete floor.
- ☐ Wait three or more days after painting to install carpet.

- ☐ Avoid urea-formaldehyde-based underlayment.
- ☐ Avoid lauap plywood underlayment.
- ☐ Specify carpet made with recycled-content face fiber.
- ☐ Specify carpet tiles made with recycled-content backing.
- ☐ Specify natural fiber carpets.
- ☐ Specify carpet from manufactures who will recycle used carpet.
- ☐ Use only very-low-VOC carpet adhesives.
- ☐ Use hook-and-loop tape rather than adhesives.
- ☐ Use tackless-strip rather than glue-down carpet installation.

13. PAINTS AND COATINGS

- ☐ Specify zero-VOC interior latex paints.
- ☐ Specify paints made from plants and minimally processed minerals.
- ☐ Maximize direct-to-outdoors ventilation when applying paint.

14. ELECTRICAL

- ☐ Size electrical cables appropriately.
- ☐ Specify only low-mercury fluorescent lamps.

Concrete Floors

A Factsheet from Mission Viejo's Green Building Program

Concrete finish floors are good for your nose and your bottom line because they are an energy efficient and environmentally sound option for your home or business.

Concrete finish floors are a good choice for:

- **Aesthetics** — A wide range of attractive colors and patterns are available (depending on finish type) to compliment any design scheme.
- **Easy cleaning and maintenance** — Only needs mopping and an occasional resealing or rewaxing.
- **Durability** — Concrete never needs replacing.
- **Energy efficiency** — The mass of concrete helps stabilize indoor temperatures and takes advantage of Mission Viejo's ideal ground temperature.
- **Allergy relief** — Concrete won't hold dust, mold, dust mites, or pollens like carpeting can.
- **Keep cool** — Concrete stays cool like ceramic tile.
- **Economics** — Concrete finish floors save on long-term costs like energy bills, maintenance, and replacement.
- **Environmental** — Concrete finish floors conserve resources by using the same material to perform two functions--foundation and finish floor.
- **Flexibility** — Allows you to change the look of your home or business by rearranging area rugs/area floor coverings, without the expense of tearing out carpet or tile.

Price and durability depend on the coloring method used:

Option 1 - Dye added to concrete mix at the plant. Integral color hides chipping but is not commonly done due to high cost.

Option 2 - Dye powder sprinkled onto concrete at finish stage and troweled in by concrete installer. Color is slightly below the surface, so minor chipping is hidden, more economical than option 1.

Option 3 - Color stain applied to the surface of the concrete after it has dried completely. Good for remodeling as well as new construction, unlimited palette, pattern, and price.

When and how to plan for concrete staining:

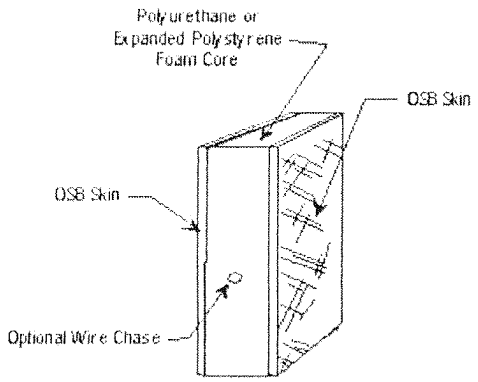
- When planning to use integrally colored concrete, optimize the use of concrete by designing your foundation to use just enough but not too much, since integral color has a higher cost.
- Scoring and staining is possible for all concrete surfaces: steps, porches, patios, sunspaces, countertops, and fireplace surrounds.
- Extreme care must be taken at every stage of the construction process when staining is to be employed:
  - Be sure to write all special conditions into your subcontractor specifications/agreements.
  - Supplement this by telling all subcontractors that the floor is to be finished and exposed, and that they are responsible for stains from adhesives, coffee, sodas, and chipping from falling tools or tear-outs. Plumber's adhesive and red chalk are particularly detrimental. Plumber's adhesive will bleach the floor and prevent it from taking the stain properly. Red chalk cannot be removed from the floor—blue chalk is okay. Sawdust, lumber, and construction debris must be kept off the floor at all times as these can draw moisture out of the concrete, affecting the staining process - be diligent and repeat yourself when necessary.
  - Protect the floor after staining with cardboard or silverboard, and make sure you work the replacement costs for these items into your bidding.

Basic SIPs

(Structural Insulated Panels)

A Factsheet from Mission Viejo's Green Building Program

Structural Insulated Panels (SIPs) can be substituted for wood framed walls, floors, and roof/ceilings when building an energy-conscious home.



Structural Insulated Panels (SIPs) are relatively new to the building marketplace and are growing in acceptance with builders, developers, and homeowners. SIPs currently represent less than 1 percent of all residential/light construction (8,000 homes per year), with 5 percent anticipated growth according to the Structural Insulated Panel Association (SIPA) the product's trade association. As a direct substitute for wood framing and infill insulation, SIPs offer considerable energy and resource conserving advantages. A SIP is a panel with a core of insulation (either the white expanded polystyrene or the yellow-orange polyurethane) sandwiched between various skins of metal, drywall, or oriented strand board (OSB). As blank slabs or pre-engineered with door and window openings cut out, SIPs arrive at the site, are unloaded, uprighted, fastened, and the framing stage is complete. Speedy installation is not the only advantage to SIP construction, though. They also promote excellent energy efficiency due to their continuous foam cores, and because they can come in lengths up to 28 feet, fewer joints means fewer points of air entry, further reducing energy bills. SIPs typically come in 8-foot heights and can be stacked up to three stories high without additional bracing requirements. Cathedral ceilings and exposed beam details can be simplified by using SIP construction as one roof panel can form structure, insulation, sheathing, and sheet rock attachment. SIPs can be clad with most conventional sidings, and they work within standard wood framing dimensions which makes it easy on your contractor. In addition, buildings using SIPs are stronger than stick-built structures. They can withstand winds in excess of 160 mph, ground movement, freeze and thaw movement, and seismic class 4 standards.

When choosing a SIP, look for:

- **Non ozone-depleting foam cores**--All expanded polystyrene foams are now produced without CFCs/HCFCs, polyurethane foams may or may not use CFCs/HCFs.
- **Low formaldehyde content skins**--Formaldehyde is a necessary ingredient in engineered wood products, but new adhesives retain formaldehyde rather than letting it leach off into indoor air.
- **Engineered testing of the panels for any building application**--Different manufacturers have different tests which certify different structural aspects of their products. You want a panel which will do all that you need it to and has the engineered testing to prove it to you and local building officials.
- **Excellent product support**--Is the manufacturer willing to come out to your site and help train you or your contractor?
- **Make sure SIPs match your project's priorities**--If your project's priorities are quick dry-in time, tight energy-efficient construction, wood frame modularity, and cost (SIPs are competitive to stick framing if installed with unskilled labor in Mission Viejo), SIPs are a good product choice.

When planning a SIP building, be sure to include exhaust fans for the removal of bathroom, laundry, and kitchen odors and humidity. The tight construction afforded by SIPs can create indoor humidity above recommended levels, which can be remedied with fans to remove unwanted indoor air pollutants at their source.

Use project life-cycle financing mechanisms. Another option for funding Category Three options (those that add up-front cost but also pay for themselves over time) is to use life-cycle financing mechanisms. Life-cycle financing considers the total anticipated costs over the lifetime of the building, or the financing payback period. (Life-cycle costs are explained in the box below.) Life-cycle financing programs can help increase the amount of up-front financing available to cover costs that will reduce the net operating expenses. One example is HUD's Energy Efficient Mortgage Insurance Program, which can finance energy efficiency measures at up to $8,000 per new home. The program can also fund rehabilitation projects. Another example is Fannie Mae's Housing and Environment Initiative that offers increased financing to individual homebuyers installing energy efficiency measures. Another type of life-cycle financing is the location-efficient mortgage, which recognizes that home occupants in urban locations have lower transportation costs and therefore may qualify for higher financing amounts (that can be applied to sustainable building strategies). One example is Fannie Mae's Location Efficient Mortgage Program.

The Importance of "Life-Cycle Costing" and the "Payback Period"

Tribes often need to work within a fixed budget in their building projects. For example, residential projects funded with HUD grants will have a very tight fixed budget per unit. However, when the tribe does have an option increasing the up-front costs to cover certain sustainable building approaches, it can result in substantial savings down the road.

"Life-cycle costs" refer to all costs related to a building (or other product) over a specified period of time. Life-cycle costs include not only the up-front costs, but also the following:

- Operating costs, such as building energy costs for electricity or heating, or water costs.
- Maintenance and repair costs, such as the cost to repair appliances and other building systems when they break. Some devices can be simple and inexpensive to repair; others may require specialized, high-cost service or parts.
- Replacement costs vary directly with the expected life of a product, such as a washing machine. The longer a product lasts, the lower the overall replacement costs.
- Disposal costs, such as the cost to gather and send waste to a landfill.
- Externalized environmental and social costs, though hard to quantify, include the impacts associated with producing and using products (for example, loss of scarce natural resources, loss of habitat, and air and water pollution).

For example, increasing a 10,000 square-foot commercial building's insulation rating from R-19 to R-38 may increase up-front costs by about 35 cents per square foot, or $3,500. However, a contractor can easily calculate the estimated annual energy cost savings of the added insulation for the particular location and building type. The annual savings could be in the neighborhood of $250 per year, or $5,000 over a 20-year planning period. In this example, there would likely be no significant differences in maintenance, repair, or disposal costs for the two different types of insulation. By using less energy, the building would reduce the amount of energy resources required for its operation, and the associated air pollution involved in producing electricity for heating.

Any option that adds up-front costs while decreasing lifecycle costs will have a payback period, the time required for the annual savings to equal the original up-front cost. In the above example, the additional cost of the R-38 insulation was $3,500. At an annual energy savings of $257, the insulation would pay for itself in about 14 years. In other words it would have a payback period of about 14 years.

Recycling levels for construction projects in the range of 60 to 70 percent can be achieved, but availability of local markets is critical to achieving this level of recycling. One Portland project achieved a 76 percent recycling level, comprised of recyclable or reusable wood (61 percent), cardboard (11 percent) and gypsum wallboard (4 percent). Excellent technical assistance is available to assist in developing an on-site waste reduction plan and incorporating recycling requirements into bid and contract language. (See the resources at the end of this module.) Disposal costs vary by region and by the particular practices employed. In a 1995 survey, contractors reported paying between $250 and $1,000 per home for waste removal and disposal, not including revenue from recyclables.[2] Reducing material use by using strategies like standard dimensions in framing and modular components can reduce costs on a typical home by nearly $1,000 while reducing the amount of materials used and wasted.

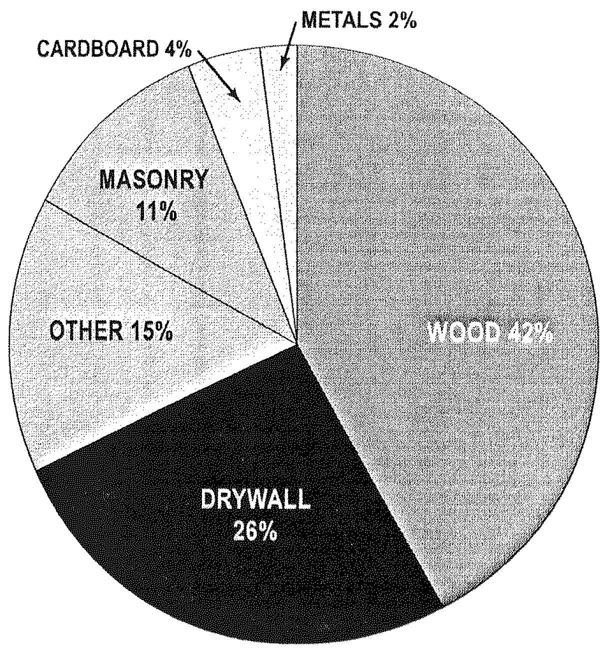
RECYCLABLE CONSTRUCTION MATERIALS

Land Clearing Debris
Clean, Dimensional Wood
Plywood and Particle Board
Concrete
Asphalt Concrete
Concrete Masonry Units
Bricks
Gypsum Wallboard
Rigid Foam Insulation
Asphalt Shingles
Paint
Window Glass
Carpet and Pads
Plastic Film
Polystyrene
High Density Polyethylene
Cardboard, Paper and Packaging

Source: U.S. Green Building Council, LEED Reference Package Version 2.0.

Rehabilitate existing buildings. One environmentally desirable form of green building involves the reuse of existing buildings. This may involve merely reusing the shell or components of the shell, or additional components like plumbing, interior walls, etc. This can have several mutually reinforcing benefits, including eliminating the need for demolition and landfilling of on-site materials, eliminating the need to produce lumber and the many other products used on site, eliminating transportation costs, etc. It also reduces construction waste considerably. Also, rehabilitating existing buildings may contribute to the rebirth of neighborhoods and saving artifacts of community interest into the future. Finally, infrastructure like electricity, water, and sewage are all likely to be in place already. On the other hand, energy efficiency and other improvements will likely be necessary, and environmental review is essential to determine whether hazardous or toxic materials are present. Check compliance with safety and fire codes as well as adaptability to the new building's design. In one example, the Southern California Gas Company reused an existing building in a 44,000 square-foot project and saved an estimated $3.2 million, including savings on masonry (87 percent savings), site work (57 percent savings), concrete (49 percent savings) and carpentry (70 percent savings).[3]

CONSTRUCTION WASTE BY WEIGHT

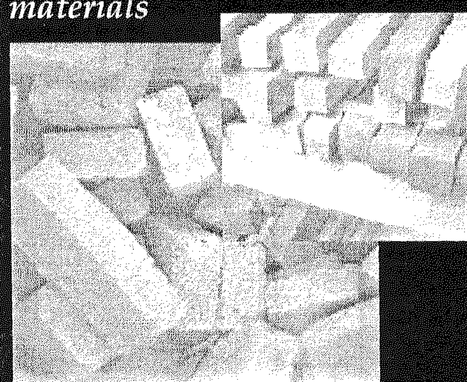


NAHB, Residential Construction Waste Management: A Builder's Field Guide.

Construction and Demolition/ Deconstruction Waste Management. There are a number of ways to reduce demolition waste including reuse and recycling. But prior to demolition of a building, deconstruction of the building should take place. This is the removal of the more valuable materials such as doors, windows, cabinets, millwork, paneling, dimensional lumber, plumbing fixtures, electrical fixtures and wiring, HVAC equipment, and architectural fixtures. These materials can be reused in the same project or because of their high resale value can be sold for use or other projects.

Materials that have a lower resale value often are reused on-site. Clean lumber can be chipped into mulch and later used for landscaping; water damaged wood can be composted and used as a soil amendment. Additionally clean concrete and masonry as well as bricks can be reused on the project, although it may not be cost-effective to deconstruct these materials. However, they may be crushed on-site and used as aggregate fill for the new project.

Wood and bricks are two recyclable construction materials



After all of the reusable items are removed, the remaining building is demolished and the easily recyclable materials are separated. These materials include steel and other metals, tile, asphalt, concrete, masonry, and bricks. In most areas there are well-developed markets for these products, especially steel and metal. The remaining materials are usually crushed for use in road construction. There are many companies that process this material with significant amounts used by CalTrans and local municipalities.

Design to facilitate recycling and reuse. Buildings can be designed from the beginning to facilitate recycling and waste reduction practices by the occupants. The specific needs will vary depending on the type of building, but in general there is a need for a dedicated space for storing and/or processing recyclables that is convenient. In a single-family home this might mean a space in a garage or utility room. In a multi-family complex it would mean a covered area large enough for one or more dumpsters. In a commercial building it could mean designating multiple locations to place recycling bins in offices or storage areas near a loading dock with waste paper balers or other equipment, depending on the type of operation. A 1991 State law required all California cities and counties to adopt ordinances requiring space allocating new construction for recycling. To date, dozens of municipalities have complied with this law. In those that have not adopted an ordinance, a model ordinance prepared by the California Integrated Waste Management Board is in effect by default. This ordinance can also serve as a model for Tribes. (See link in the resources section.) Landscaping too can be designed from the beginning to reduce waste, for example, by using native plants that require little maintenance. (Landscaping is covered in Module 7, Water Efficiency and Landscaping).

Specify products that can be repaired, renovated, or partially replaced. Over the lifetime of the building, adopting a strategy of repairing and renovating, rather than replacing products or building components when they become obsolete, can reduce waste. This involves researching product durability, reparability, and replacement issues. It also means considering the entire lifecycle costs of products and building components from the outset. For example, commercial carpet tiles can be specified that can be replaced one at a time. This allows building managers to "repair" a carpet when needed in high traffic areas, significantly reducing the cost of replacing carpet in the entire space and reducing associated carpet waste. But such benefits are contingent upon the building construction team specifying commercial carpet tiles from the outset. By considering the potential to extend product life through repair or renovation, similar benefits may be realized by specifying appliances and building components that can be repaired or renovated when they fail or become obsolete, rather than being replaced outright.

PART 6. INDOOR ENVIRONMENTAL QUALITY

Indoor air pollutants can often be four to five times higher than outdoor levels.
• The trend of making buildings tighter has the unintended consequence of people breathing the same air (and vapors of products) over and over.
• Studies show that buildings with good overall environmental quality can reduce the rate of respiratory disease, allergy, asthma, sick building symptoms, and enhance worker performance.

CONTOL OF OUTDOOR POLLUTION

- ☐ Avoid pollution by locating building away from sources of pollution.
- ☐ Research previous uses of the site.
- ☐ Use least-toxic pest-control before and during construction.
- ☐ Locate outdoor intakes away from pollution sources.
- ☐ Keep positive pressure in the building (through proper HVAC design).
- ☐ Reduce intake of outside air when outdoor traffic pollution is highest.
- ☐ Seal openings in building envelope & interstitial spaces to control migration of contaminants.
- ☐ Design to prevent soil gas entry.
- ☐ Check for and minimize radon within the structure.
- ☐ Design entry to facilitate removal of dirt from shoes before entering the building.
- ☐ Avoid carpet and other hard-to-clean floor surfaces near entry.

COMFORT

1. THERMAL COMFORT

- ☐ Use glazing with a low Solar Heat Gain Coefficient.
- ☐ Use glazing with a minimum U-value of 0.33 when occupants will be next to windows.
- ☐ Maintain relative humidity levels between 30% and 60%
- ☐ Provide occupants with the means to control temperature in their area.

2. VISUAL COMFORT- Building Envelope Features

- ☐ Orient the floor plan on and east-west axis for best control of daylighting.
- ☐ Use large exterior windows and high ceilings to increase daylighting.
- ☐ Use skylights and/or clerestories for daylighting.
- ☐ Incorporate light shelves on the south façade.
- ☐ Choose interior and exterior glazing to maximize daylight transmission.
- ☐ Design open floor plans to allow exterior daylight to penetrate to the interior.
- ☐ Use low partitions near the exterior glazing to promote daylight penetration.
- ☐ Install large interior windows to allow for transmission of daylight.
- ☐ Locate floor openings under skylights to increase daylight penetration.
- ☐ Select only white to midrange finishes to maximize reflectance of light.
- ☐ Place primarily unoccupied spaces away from daylight sources.

- ☐ Use electronic ballasts with fluorescent lighting.
- ☐ Provide occupants with control of light in their area.
- ☐ Provide illumination sensors.

4. ACOUSTICAL COMFORT

- ☐ Install acoustical glazing to reduce sound transmission.
- ☐ Consider exterior noise when designing operable windows.
- ☐ Locate mechanical system motors and fans away from occupants.
- ☐ Minimize sound transmission between rooms with appropriate detailing and material Densities (including solid wall placement).
- ☐ Specify acoustically absorbent materials to lower reflected noise levels.
- ☐ Use moving water to create a pleasant acoustic environment.
- ☐ Select and install mechanical equipment based on specific low sound level targets.
- ☐ Locate refrigerators and other noisy appliances away from quiet areas; use sound baffles.
- ☐ Use air transfer grills only when acoustic transmission is not an issue, or use baffled grills.
- ☐ Seal air passages in partitions and ceilings, and around doors.
- ☐ Control duct noise with large-volume, low-velocity air systems instead of lined ducts.

VENTILATION AND AIR DISTRIBUTION

- ☐ Provide occupants with access to operable windows.
- ☐ Design for optimum cross-ventilation through window placement.
- ☐ Specify ventilation rates that meet or exceed AHSRE Standard 62-1999.
- ☐ Locate airflow monitoring devices on the outdoor air side of air handling units.
- ☐ Include high-efficiency air filtration system with prefilters and final filters.
- ☐ Provide heat-recovery ventilation.
- ☐ Design ventilation system to exchange both heat and humidity.
- ☐ Ensure that exhaust fans and air handlers do not depressurize building cavities or the soil.
- ☐ Keep negative pressure in attached garages.
- ☐ Avoid backdrafting by using sealed-combustion or power-vented combustion devises.
- ☐ Enclose gas-fired HVAC/hot water systems and vent them to the exterior.
- ☐ Have air intake for dryers come from outside, so conditioned indoor air is not wasted.
- ☐ Use duct mastic instead of duct tape, to prevent leakage in long-term.
- ☐ Keep air supply and return vents clear of obstructions.
- ☐ Specify external duct insulation rather than internal.
- ☐ Use hard-surface acoustic noise controls in ducts.
- ☐ Clean all air ducts before occupancy.
- ☐ Provide local exhaust ventilation for rooms with high-emitting sources.
- ☐ Designate a separate, well-exhausted smoking lounge is smoking is allowed in buildings.
- ☐ Install a quiet, effective fan in bathrooms.
- ☐ Use special equipment for ventilating locations with high heat loads.
- ☐ Ensure kitchen range hoods exhaust to the outdoors.

MOISTURE CONTROL

1. FOUNDATIONS

- ☐ Use wide enough eaves and gutters to keep water away from foundations.
- ☐ Use landscaping and grading to divert water away from the building.
- ☐ Use foundation perimeter rainwater collection system to divert water from building.
- ☐ Prevent water migration from beneath slab-on-grade or below-grade floors.
- ☐ Use drainage to lower the water table around the building.
- ☐ Raise the building up on piers as needed.
- ☐ Install poly vapor barriers over all exposed earth in crawl spaces and basements.
- ☐ Keep crawl spaces sealed off from outdoor air during humid weather.
- ☐ Avoid use of linoleum and vinyl flooring over uncured concrete and below-grade slabs.
- ☐ Avoid carpet on unisulated slab-on-grade or below-grade floors.

2. WALLS, ROOFS, DOORS, and WINDOWS

- ☐ Keep insulation and other construction materials dry.
- ☐ Use rooftop rainwater collection system to divert water from the building.
- ☐ Seal exterior walls and provide overhangs to prevent bulk water (rain) penetrating.
- ☐ Provide drainage plane in exterior walls to prevent bulk water (rain) penetration.
- ☐ Provide rain screen in exterior walls to prevent bulk water (rain) penetration.
- ☐ Design building envelope to avoid thermal bridging.
- ☐ Use windows that provide R-2 or better over their entire surface (R-3 is better).
- ☐ Provide special envelope and mechanical detailing for high-moisture-source spaces.
- ☐ Locate air/vapor retards near the interior surface of the building envelope.
- ☐ Locate vapor retarding layers towards the interior or near the thermal center of the wall.
- ☐ Locate air/vapor retarders near the exterior surface of the building envelope.

3. MECHANICAL SYSTEMS

- ☐ Design ductwork to allow access for cleaning.
- ☐ Use active dehumidification.
- ☐ Keep relative humidity below 60%.
- ☐ Seal any ductwork running through unconditioned space with mastic.
- ☐ Unsure that condensate pans drain properly.
- ☐ Provide easy access to coils, filters, and drain pans.
- ☐ Maintain air pressure in building and building cavities at or above outdoor pressure.
- ☐ Insulate cold water supply pipes to prevent condensation.
- ☐ Insulated chilled water piping to prevent condensation.
- ☐ Insulate outdoor air ducts in conditioned space.
- ☐ Insulate exhaust ducts in unconditioned space.

POLLUTION FROM MATERIALS

- ☐ Chose construction materials and interior finish products with zero or low emissions to improve indoor air quality.
- ☐ Provide adequate ventilation and a high-efficiency, in-duct filtration system.
- ☐ Consult a professional about testing for lead levels of old paint.

- ☐ Test for lead in drinking water and replace plumbing pipes and fixtures if necessary.
- ☐ Check old vinyl flooring and pipe insulation for asbestos.
- ☐ Review Material Safety Data Sheet when evaluating construction materials.
- ☐ Procure green-label-certified carpet.
- ☐ Test carpets for VOC emissions or procure test results.
- ☐ Specify vegetable-based form-release oil for concrete forms.
- ☐ Specify low-mercury fluorescent lamps.
- ☐ Avoid products that may release mineral fibers.
- ☐ Use finishes that are easy to clean using mild surfactants and water.
- ☐ Use only non-solvent-based adhesives.
- ☐ Use water-based floor finishes.
- ☐ Avoid the use of adhesives when installing gypsum board.
- ☐ Apply sealer to any panel products made with urea-formaldehyde.
- ☐ Avoid urea formaldehyde particleboard.
- ☐ Use only very-low or no-VOC paints.
- ☐ Use only solvent-free floor finishes for wood and stone.
- ☐ Encapsulate lead paint when removing it is not feasible.
- ☐ Seal all exposed particle board or MDF.

CONSTRUCTION AND OPERATION

- ☐ Minimize exposure of textiles and uncoated paper to high VOC concentrations.
- ☐ Store gypsum board during construction in well-ventilated areas.
- ☐ Warehouse carpet unrolled to allow airing.
- ☐ Wait three or more days to install carpet and other furnishings after painting.
- ☐ Ensure that materials containing mineral or glass fibers are properly installed and contained.
- ☐ Minimize generation of airborne particulates during construction.
- ☐ Establish protocols to control the spread of pollutants during work on occupied buildings.
- ☐ Install chlorine filter on showerhead.
- ☐ Use adequate ventilation during installation and cuing of thermal insulation.
- ☐ Ensure good ventilation during high-VOC-source applications or in confined space.
- ☐ Provide temporary filters on any permanent air-handling devices and during construction.
- ☐ Purge the building of VOCs during furniture installation prior to move-in.
- ☐ Commission (wide-range test) the mechanical and electrical systems prior to occupancy.
- ☐ Use a comprehensive commissioning process to ensure that design intent is realized.
- ☐ When using water for cleaning, ensure that materials can dry quickly.
- ☐ Avoid air handler designs that provide convenient but inappropriate storage space.
- ☐ Design for easy access to HVAC components.
- ☐ Specify routine maintenance for HVAC system and check performance of system.
- ☐ Specify use of only nontoxic cleaning products.
- ☐ Design isolated storage closet for cleaning and maintenance products.
- ☐ Install central vacuum that vents to outside
- ☐ Instruct occupants to use safe consumer products non-toxic household cleaners.

• Insect and disease problems can be effectively controlled without exposing occupants to harmful or hazardous chemical and practices.

- ☐ Use least-toxic pest-control strategies.

- Treat all cellulosic materials (e.g., wood framing) with a borate product to a minimum of three feet above the foundation, or use non-cellulosic wall structure.
- Use solid concrete foundation walls or masonry wall with top course of solid block bond beam or concrete filled block.
- Keep all wood used at least 12" above the soil and seal all cracks, joints and penetrations with calking. Install rodent and corrosion proof screens on all openings that cannot be caulked or sealed.
- Install landscaping so that all parts of mature plants will be at least 24 inches from the house.

Sources and Potential Health Effects of Indoor Air Pollutants

Pollutant	Major Indoor Sources	Potential Health Effects*
Environmental Tobacco Smoke	Cigarettes, cigars, and pipes	Respiratory irritation, bronchitis and pneumonia in children, emphysema, lung cancer, and heart disease
Carbon Monoxide	Unvented or malfunctioning gas appliances, wood stoves, and tobacco smoke	Headache; nausea; angina; impaired vision and mental functioning; fatal at high concentrations
Nitrogen Oxides	Unvented or malfunctioning gas appliances	Eye, nose, and throat irritation; increased respiratory infections in children
Organic Chemicals	Aerosol sprays, solvents, glues, cleaning agents, pesticides, paints, moth repellents, air fresheners, drycleaned clothing, and treated water	Eye, nose, and throat irritation; headaches; loss of coordination; damage to liver, kidney and brain; various types of cancer
Formaldehyde	Pressed wood products such as plywood and particleboard; furnishings; wallpaper; durable press fabrics	Eye, nose, and throat irritation; headache; allergic reactions; cancer
Respirable Particles	Cigarettes, wood stoves, fireplaces, aerosol sprays, and house dust	Eye, nose and throat irritation; increased susceptibility to respiratory infections and bronchitis; lung cancer
Biological Agents (Bacteria, Viruses, Fungi, Animal Dander, Mites)	House dust; pets; bedding; poorly maintained air conditioners, humidifiers and dehumidifiers; wet or moist structures; furnishings	Allergic reactions; asthma; eye, nose, and throat irritation; humidifier fever, influenza, and other infectious diseases
Asbestos	Damaged or deteriorating insulation, fireproofing, and acoustical materials	Asbestosis, lung cancer, mesothelioma, and other cancers
Lead	Sanding or open-flame burning of lead paint; house dust	Nerve and brain damage, particularly in children; anemia; kidney damage; growth retardation
Radon	Soil under buildings, some earth-derived construction materials, and groundwater	Lung cancer

* Depends on factors such as the amount of pollutant inhaled, the duration of exposure and susceptibility of the individual exposed.

Sick Building Syndrome

US EPA Indoor Air Facts No. 4

Introduction

The term "sick building syndrome" (SBS) is used to describe situations in which building occupants experience acute health and comfort effects that appear to be linked to time spent in a building, but no specific illness or cause can be identified. The complaints may be localized in a particular room or zone, or may be widespread throughout the building. In contrast, the term "building related illness" (BRI) is used when symptoms of diagnosable illness are identified and can be attributed directly to airborne building contaminants.

A 1984 World Health Organization Committee report suggested that up to 30 percent of new and remodeled buildings worldwide may be the subject of excessive complaints related to indoor air quality (IAQ). Often this condition is temporary, but some buildings have long-term problems. Frequently, problems result when a building is operated or maintained in a manner that is inconsistent with its original design or prescribed operating procedures. Sometimes indoor air problems are a result of poor building design or occupant activities.

Indicators of SBS include:

- Building occupants complain of symptoms associated with acute discomfort, e.g., headache; eye, nose, or throat irritation; dry cough; dry or itchy skin; dizziness and nausea; difficulty in concentrating; fatigue; and sensitivity to odors.
- The cause of the symptoms is not known.
- Most of the complainants report relief soon after leaving the building.

Indicators of BRI include:

- Building occupants complain of symptoms such as cough; chest tightness; fever, chills; and muscle aches
- The symptoms can be clinically defined and have clearly identifiable causes.
- Complainants may require prolonged recovery times after leaving the building.

It is important to note that complaints may result from other causes. These may include an illness contracted outside the building, acute sensitivity (e.g., allergies), job related stress or dissatisfaction, and other psychosocial factors. Nevertheless, studies show that symptoms may be caused or exacerbated by indoor air quality problems.

Causes of Sick Building Syndrome

The following have been cited causes of or contributing factors to sick building syndrome:

Inadequate ventilation: In the early and mid 1900's, building ventilation standards called for approximately 15 cubic feet per minute (cfm) of outside air for each building occupant, primarily to dilute and remove body odors. As a result of the 1973 oil embargo, however, national energy conservation measures called for a reduction in the amount of outdoor air provided for ventilation to 5 cfm per occupant. In many cases these reduced outdoor air ventilation rates were found to be inadequate to maintain the health and comfort of building occupants. Inadequate ventilation, which may also occur if heating, ventilating, and air conditioning (HVAC) systems do not effectively distribute air to people in the building, is thought to be an important factor in SBS. In an effort to achieve acceptable IAQ while minimizing energy consumption, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) recently revised its ventilation standard to provide a minimum of 15 cfm of outdoor air per person (20 cfm/person in office spaces). Up to 60 cfm/person may be required in some spaces (such as smoking lounges) depending on the activities that normally occur in that space (see ASHRAE Standard 62-1989).

Chemical contaminants from indoor sources: Most indoor air pollution comes from sources inside the building. For example, adhesives, carpeting, upholstery, manufactured wood products, copy machines, pesticides, and cleaning agents may emit volatile organic compounds (VOCs), including formaldehyde. Environmental tobacco smoke contributes high levels of VOCs, other toxic compounds, and respirable particulate matter. Research shows that some VOCs can cause chronic and acute health effects at high concentrations, and some are known carcinogens. Low to moderate levels of multiple VOCs may also produce acute reactions. Combustion products such as carbon monoxide, nitrogen dioxide, as well as respirable particles, can come from unvented kerosene and gas space heaters, woodstoves, fireplaces and gas stoves. For more information, see VOCs; Carbon Monoxide; Formaldehyde; Nitrogen Dioxide; Respirable Particles.

Chemical contaminants from outdoor sources: The outdoor air that enters a building can be a source of indoor air pollution. For example, pollutants from motor vehicle exhausts; plumbing vents, and building exhausts (e.g., bathrooms and kitchens) can enter the building through poorly located air intake vents, windows, and other openings. In addition, combustion products can enter a building from a nearby garage.

Biological contaminants: Bacteria, molds, pollen, and viruses are types of biological contaminants. These contaminants may breed in stagnant water that has accumulated in ducts, humidifiers and drain pans, or where water has collected on ceiling tiles, carpeting, or insulation. Sometimes insects or bird droppings can be a source of biological contaminants. Physical symptoms related to biological contamination include cough, chest tightness, fever, chills, muscle aches, and allergic responses such as mucous membrane irritation and upper respiratory congestion. One indoor bacterium, Legionella, has caused both Legionnaire's Disease and Pontiac Fever. For more information, see Biologicals and Mold.

These elements may act in combination, and may supplement other complaints such as inadequate temperature, humidity, or lighting. Even after a building investigation, however, the specific causes of the complaints may remain unknown.

IMPLEMENTATION

The concepts and details presented in this tool kit are only as good as the ability to implement them on both project and large scale. Many resources are available to leaders to help assure implementation, including codes, checklists and trainings.

PART 7. BUILDING ENERGY CODES, PLANNING & POLICY

Tribes are in a position to implement comprehensive, long-range vision for sustainability.

- The sovereign status of Arizona Indian nations presents exciting decision-making opportunities for tribal members, councils, planners, and staff when it comes to developing or adopting building codes and construction guidelines that improve energy conservation.
- Arizona is a home rule state so each jurisdiction within the state is encouraged to adopt their own codes and provide compliance measures to support those codes.

Few of Arizona's tribes have formally adopted building codes; some tribes formally abide by the county, State, or federal building codes. By creating new plans and laws, tribes can greatly influence the transition to more sustainable building in unique ways, compared to non-Indian jurisdictions. However, in addition to acting as regulatory authority, they may simultaneously act as regulatory authority, owner-operator, developer-builder, or client community:

▶ As sovereign authority and lead regulator, Tribes may:

- ☐ Adopt a communitywide approach covering residential, commercial, and institutional buildings, and both indoor and outdoor built environments.
- ☐ Incorporate green building methods into generals plans, building codes, remodeling permits, contractor specifications, or contract and bid language.
- ☐ Fully revise procurement policies to reflect green building criteria.
- ☐ Require green building principles to be incorporated in tribal planning documents.
- ☐ Provide green building educational materials and/or revise and amend current building plans and acquisition goals.
- ☐ Subsidize renewable energy systems on tribal lands.
- ☐ Encourage tribal staff to seek special sources of green building funds.

▶ As owner-operator of the built environment and land base, the tribe may:

- ☐ Initiate the design and building process.
- ☐ Define needs and establish building criteria.
- ☐ Create a design vision reflecting the community as a whole.
- ☐ Exercise leadership to determine the best building approaches.

▶ As developer and builder, the tribe may:

- ☐ Determine the scope of work, timelines, and contractual objectives.
- ☐ Select contractors and architects that reflect green building objectives consistent with the tribe's philosophies and vision.
- ☐ Take actions, such as making purchasing decisions, that reflect new green building policy directions.

- Revise work plans for current building projects to reflect new green building policies.

► As client and community, the tribe may:
- Express community needs and desires.
- Participate in the planning and design process.
- Provide feedback on building use and comfort, and suggest new approaches.

As initial steps in regulating building on reservations, tribes generally adopt basic building codes such as the:
- International Residency Code (IRC)
- International Commercial Building Code (IBCC)
- International Plumbing Code, and
- International Electrical Code.

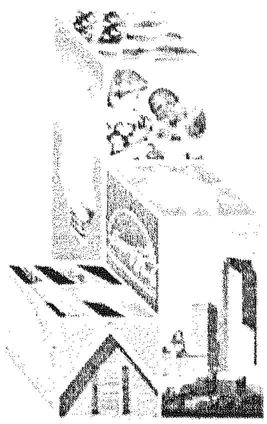
To support sustainable building and energy conservation a next step is the adoption of the:
- International Energy Conservation Code (IECC) 2006. It is referred to as the Model Energy Code (MEC). This is a minimal code with no checks on actual performance of buildings required.

One higher step towards energy conservation is to adopt the:
- US Energy Star Program, which requires at least 15% better energy performance than the IECC/ MEC. Energy Star does require that performance be tested to receive the Energy Star Certification.

Each power company in Arizona has their own programs to encourage energy conservation, and some offer tax rebates if certain performance levels are met.
- Check with you local power company about how to participate in energy conservation and energy incentive programs.

When working as a team and talking with builders it is handy to have printed guidelines and checklists handy.
- The National Association of Home Builders has a good checklist, which can be found at www.nahbrc.org/greenguidelines/checklist.htm.
- For free software to help with efficient energy design refer to the Department of Energy's Building Energy Codes Program on the web at www.energycodes.gov/ for their free REScheck, and COMcheck programs for residential and commercial buildings.

More and more leaders and builders are expressing a willingness to design and build sustainable, yet insist that they need new codes and policy guidelines to work from, and to "keep the playing field level" between businessmen.
- Use your tribal meeting and decision process to get started and make incremental steps.
- Inform and educate your leaders and key stakeholders to incrementally achieve consensus on key steps.
- Adopt into law vision and values statements that will be long-enduring and provide guidance, education, and incentives to sustain the process indefinitely.



Buildings for the 21st Century

Buildings that are more energy-efficient, comfortable, and affordable...that's the goal of DOE's Office of Building Technology, State and Community Programs (BTS). To accelerate the development and wide application of energy efficiency measures, BTS:

- Conducts R&D on technologies and concepts for energy efficiency, working closely with the building industry and with manufacturers of materials, equipment, and appliances
- Promotes energy/money saving opportunities to both builders and buyers of homes and commercial buildings
- Works with State and local regulatory groups to improve building codes, appliance standards, and guidelines for efficient energy use
- Provides support and grants to States and communities for deployment of energy-efficient technologies and practices

CODES & STANDARDS

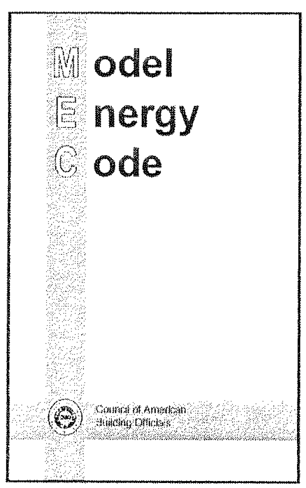
THE MODEL ENERGY CODE

What is the Model Energy Code?

The Model Energy Code (MEC), published and maintained by the International Code Council (ICC) as the "International Energy Conservation Code" (IECC) as of 1998, contains energy efficiency criteria for new residential and commercial buildings and additions to existing buildings. It covers the building's ceilings, walls, and floors/ foundations; and the mechanical, lighting, and power systems.

What editions of the MEC are available?

The MEC was first published in 1983, with subsequent full editions published in 1986, 1989, 1992, 1993, and 1995. The 1998 IECC is the successor to the 1995 MEC.



What edition of the MEC is enforced in my state?

A current list is available at www.energycodes.org. While some states have adopted the MEC without modifications, some states adopt one of the MEC editions with state-developed amendments. Still others adopt the MEC as recommended practice but have no state-wide requirement that all new construction use it.

Who developed the MEC?

The MEC was originally developed jointly (under the auspices of the Council of American Building Officials, CABO) by Building Officials and Code Administrators International, Inc. (BOCA), International Conference of Building Officials (ICBO), National Conference of States on Building Codes and Standards (NCSBCS), and Southern Building Code Congress International (SBCCI), under a contract funded by the U.S. Department of Energy.

What buildings must comply with the MEC?

The MEC applies to all new residential and commercial buildings, and additions to such buildings. *Residential buildings* are defined as detached one- and two-family dwelling units (referred to as single-family buildings or Type A1 in

For more information about the DOE Office of Building Technology, State and Community Programs, contact:

Energy Efficiency and Renewable Energy Clearinghouse (EREC)
1-800-DOE-3732
www.eren.doe.gov/buildings

Codes and Standards Home Page:
www.energycodes.org

For more information on MECcheck™ contact:

Stephen J. Turchen
Phone: ***202-586-6262***
FAX: 202-586-4617
Email:
Stephen.Turchen@ee.doe.gov

The Model Energy Code can be obtained from the International Code Council by calling ***703-931-4533.***

MECcheck™ materials *can be ordered from DOE by calling 1-800-270-CODE or downloaded directly from the Web at:* ***www.energycodes.org/resid/resid.htm***

HOTLINE:
1-800-270-CODE (2633)

Printed with renewable – source ink on paper containing at least 50% wastepaper, including 20% post consumer waste.

November 1999
DOE/GO-10099-934

the MEC). Multifamily buildings three stories or less in height above grade must also comply with the MEC. Multifamily buildings, such as apartments, townhouses, and rowhouses that have three or more attached dwelling units and are referred to as type A2 in the MEC. *Commercial buildings* are defined as all buildings other than residential type A1 or A2, plus those residential buildings that are four stories or more in height above grade.

What additions must comply with the MEC?

Additions to residential buildings must be heated and/or cooled for the MEC to apply. Additions that are not heated and/or cooled, such as an unconditioned garage, need not comply. Energy-using systems that serve the addition must also comply with the MEC. For example, all new ductwork to an addition from an existing heating system must be insulated and sealed in accordance with the code.

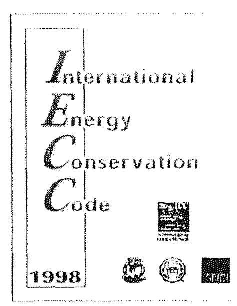
How do I demonstrate compliance with the MEC?

Commercial buildings must use ASHRAE Standard 90.1-1989 by reference, the 90.1 codified version, or Chapter 7 of the 1998 IECC. The U.S. Department of Energy has developed COM*check-EZ*™, a simple, prescriptive approach to demonstrating compliance with commercial energy codes. Methods for residential buildings include the use of a computerized building simulation tool to determine the energy use of the proposed design; a component-by-component approach that uses tables in the code appendix; and a whole building trade-off approach. The U.S. Department of Energy has developed a compliance tool set, MEC*check*™, which makes it fast and easy for designers and builders to determine if new homes and additions to existing homes meet the MEC requirements.

How are changes made to the MEC?

The MEC is revised on a regular cycle through an open public-hearing process sponsored by the ICC. Anyone wanting to suggest a revision to the MEC can request a code change form, prepare a recommended change and substantiation, and participate in open public debate. For those who wish to suggest changes to the code, contact ICC at (703) 931-4533. All proposed changes are published and distributed for review prior to an open public hearing. Testimony for and against each change is heard, and a committee votes on a recommendation for each code change. The results of this first hearing are then published. Those wishing to have a proposed code change reconsidered and discussed at a second public hearing may submit a challenge to the committee's recommended action. Based on arguments at the second hearing, building officials could vote to overturn the committee's recommendation.

A new edition of the MEC (appearing every three years) or supplement to the previous edition (in years when a new edition does not appear) is published around the spring of each year.



How can I get a copy of the MEC?

Copies of the MEC are available from the model code organizations:

BOCA at (708) 799-2300
ICBO at (562) 699-0541
SBCCI at (205) 591-1853

Building Energy Codes Program

DOE's Building Energy Codes Program is an information resource on national model energy codes. We work with other government agencies, state and local jurisdictions, national code organizations, and industry to promote stronger building energy codes and help states adopt, implement, and enforce those codes.

The Program recognizes that energy codes maximize energy efficiency only when they are fully embraced by users and supported through education, implementation, and enforcement.

Free Software

RES*check*

RES*check*, RES*check-Web*, RES*check* Package Generator

COM*check*

COM*check*, COM*check-Web*, COM*check* Package Generator

Technical Support

Resource Center

Resource Center

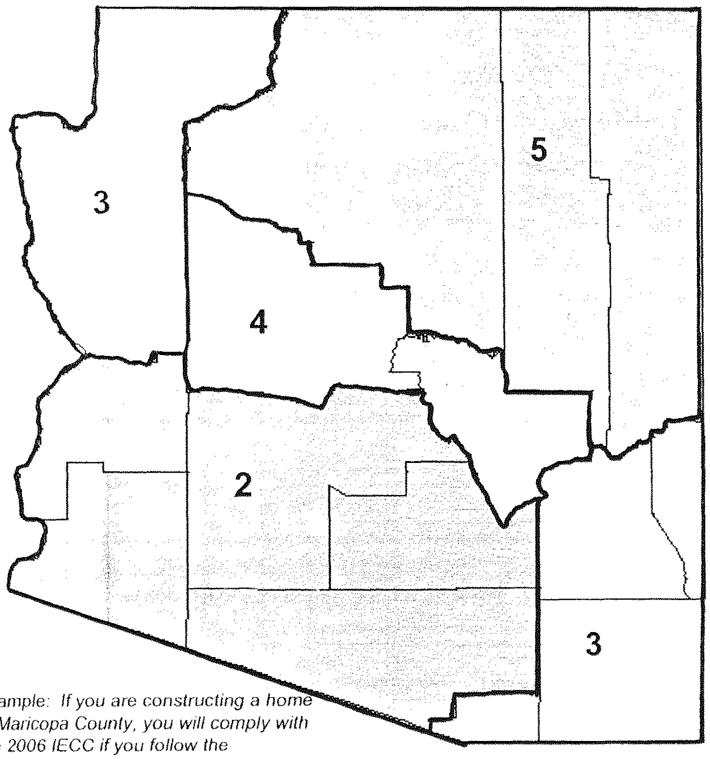
Ask an Energy Codes Expert

Ask an Expert

Last updated: 15 May 2007

IECC Compliance Guide for Homes in Arizona

Code: 2006 International Energy Conservation Code



Example: If you are constructing a home in Maricopa County, you will comply with the 2006 IECC if you follow the requirements for Climate Zone 2.

The IECC assigns the counties in the state of Arizona into four climate zones. The envelope performance requirements vary for each zone as detailed in the building requirements found on the back of this sheet.

IECC Climate Zone 2
La Paz Maricopa Pima Pinal Yuma

IECC Climate Zone 3
Cochise Graham Greenlee Mohave Santa Cruz

IECC Climate Zone 4
Gila Yavapai

IECC Climate Zone 5
Apache Coconino Navajo

Step-by-Step Instructions

1. Use the color-coded map or list of counties to locate the IECC climate zone in which construction is taking place.

2. Use the "Table of IECC Building Envelope Requirements for Arizona" (on the back of this sheet) to determine the envelope performance requirements associated with the climate zone.

3. Construct the building according to the envelope performance requirements and comply with certain other basic code requirements, which include:
   a. providing preventative maintenance manuals
   b. attaching a permanent certificate listing insulation, window and HVAC performance information
   c. installing temperature controls
   d. limiting window and door leakage
   e. caulking or sealing joints and penetrations
   f. installing vapor retarders (in certain circumstances)
   g. sealing and insulating ducts

Limitations

This guide is an energy code compliance aid for Arizona based upon the 2006 IECC. It does not provide a guarantee for meeting the IECC. The guide is not designed to reflect the actual energy code, if any, in Arizona and does not, therefore, provide a guarantee for meeting the state energy code. For details on Arizona's energy code, please contact your local building code official.

The 2006 International Energy Conservation Code

The 2006 IECC was adopted during the 2005 International Code Council (ICC) code cycle and is currently available to states for adoption. It is published by the International Code Council. For additional details or to obtain a copy of the 2006 IECC, contact the ICC by phone or visit their website at www.iccsafe.org.

The IECC is the national model energy standard certified by the U.S. Department of Energy pursuant to the Energy Policy Act (EPAct). EPAct requires that all states review and consider adopting the IECC as the state building energy code.

Table of IECC Building Envelope Requirements for Arizona

Prescriptive Path for Compliance with the 2006 IECC

WINDOWS AND INSULATION / FOUNDATION TYPE

Package	Window U-factor	Skylight U-Factor	Window and Skylight SHGC	Ceiling R-Value	Wood Frame Wall R-Value	Mass Wall R-Value	Floor R-Value	Basement Wall R-Value	Slab R-Value and Depth	Crawl Space Wall R-Value
Climate Zone 2	0.75	0.75	0.40	R-30	R-13	R-4	R-13	R-0	R-0	R-0
Climate Zone 3	0.65	0.65	0.40	R-30	R-13	R-5	R-19	R-0	R-0	R-5/13
Climate Zone 4	0.40	0.60	NR	R-38	R-13	R-5	R-19	R-10/13	R-10, 2 ft.	R-10/13
Climate Zone 5	0.35	0.60	NR	R-38	R-19 or 13+5	R-13	R-30	R-10/13	R-10, 2 ft.	R-10/13

"NR" means no requirement is specified in this package.

NOTES:

1. This table applies to new construction, as well as all additions, alterations and replacement windows and is based upon the envelope performance requirements for Climate Zones 2-5, Table 402.1.1 in the 2006 IECC, and does not reflect any state-specific amendments to the IECC. This table applies to residential buildings, as defined in the IECC, with wood framing and/or mass walls. For steel-framed buildings, refer to Section 402.2.4 of the IECC.

2. Window refers to any translucent or transparent material (i.e., glazing) in exterior openings of buildings, including skylights, sliding glass doors and glass block, along with the accompanying sashes, frames, etc.

3. Window and skylight U-factor and SHGC values are maximum acceptable levels. An area-weighted average of fenestration products shall be permitted to satisfy the U-factor and SHGC requirements. Window U-factor and SHGC must be determined from a National Fenestration Rating Council (NFRC) label on the product or from a limited table of product default values in the IECC. Up to 15 square feet of glazed fenestration is permitted to be exempt from the U-factor and SHGC requirements.

4. The code requires that windows be labeled in a manner to determine that they meet the IECC's air infiltration requirements; specifically, equal to or better than 0.30 cfm per square foot of window area (swinging doors below 0.50 cfm) as determined in accordance with NFRC 400 or AAMA/WDMA/CSA 101/I.S.2/A440 by an accredited, independent laboratory.

5. Opaque exterior doors must meet the window U-factor requirements. One exempt door is allowed.

6. Insulation R-values are minimum acceptable levels; R-19 shall be permitted to be compressed into a 2x6 cavity. R-values for walls represent the sum of cavity insulation plus insulated sheathing, if any.

7. If structural sheathing covers 25% or less of the exterior, insulated sheathing is not required where structural sheathing is used. If structural sheathing covers more than 25% of the exterior, structural sheathing shall be supplemented with insulated sheathing of at least R-2.

8. Supply and return ducts shall be insulated to a minimum of R-8. Ducts in floor trusses shall be insulated to a minimum of R-6.
   Exception: Ducts or portions thereof located completely inside the thermal building envelope.

9. Where there are two different values for basement and crawl space insulation requirements, the first R-value applies to continuous insulation, the second to framing cavity insulation. Crawl space wall R-value shall only apply to unventilated crawl spaces; R-5 shall be added to the required slab edge R-values for heated slabs; and floors over outside air must meet ceiling requirements.

10. Prescriptive packages are based upon normal HVAC equipment efficiencies (NAECA minimums). The code also requires the HVAC system to be properly sized using a computational procedure like the ASHRAE Handbook of Fundamentals.

SAMPLE HYBRID PROGRAM

TOWN OF DEWEY-HUMBOLDT
P.O. BOX 69
HUMBOLDT, AZ 86329
Phone 928-632-8643 ▪ Fax 928-632-7365

ARIZONA'S COUNTRY TOWN

ENERGY SAVING Construction

Dear Architect, Designer; Builder/Developer,

The Town of Dewey-Humboldt has been incorporated for two years. As a young Town, we are now considering a **voluntary** *Energy Saving* (not certified Energy Star) options program for residential projects.

This paper points out some of the *Energy Saving* items that might be built into these homes. The locally built homes with these features will receive recognition from the Town as an *Energy Saving* home.

You are invited to review the below list and provide me with feedback with your thoughts as to your company involvement in the program, and possible modifications to the list:

- ☐ Home orientation, preferable East-West roofline (plus/minus 15 degrees)
- ☐ Provide solar heated water or pre-wire, pre-plumb for solar water heating
- ☐ Proper roof overhang design to prevent summer overheating on South side
- ☐ Wood/Vinyl Windows with U-.3, metal windows U-.4 to be thermo-broken
- ☐ Low E windows on South, with insulating blinds, planting deciduous trees
- ☐ Low-E windows on East and West; with minimum windows on the West.
- ☐ Minimum number of Low-E windows on North, planting of evergreen trees
- ☐ Properly Installed minimum of R-19 walls and Crawl Space, R-30 ceiling
- ☐ Apply foam at interior and exterior walls, sill and plate penetrations.
- ☐ Seal joints, foam covers for receptacle and switch covers, caulk windows and doors
- ☐ Conduct blower door test
- ☐ Heating 90% efficient, and cooling SEER of 14
- ☐ Supply and return ducts insulated to R-8, and mastic sealed. N1103.2.1
- ☐ Provide box of filters and filter cleaning schedule (once a month, etc.)
- ☐ Setback thermostat installed and homeowner educated in use
- ☐ ENERGY STAR light fixture and appliances
- ☐ Insulated or blanketed Water Heaters, electric with timer
- ☐ Minimum of 75% of lighting fluorescent or compact fluorescent
- ☐ Exterior lighting with motion detectors

If your plan is to join the Town Energy Saving building program we will add this amendment to the plans and inspect to the above guidelines and provide a **Town of Dewey-Humboldt Energy Savings** window decal for those homes that successfully meet all requirements.

Terry Ford,
Building Official
terryjford@cableone.net

HOW TRIBES CAN IMPLEMENT SUSTAINBLE BUILDING PRACTICES

This module provides some practical suggestions on how to start implementing sustainable building practices.

Sustainable Building Strategies for Indian Tribes

- ✓ *At a minimum, begin by using a few select green elements.*
- ✓ *Find and work with qualified sustainable building professionals.*
- ✓ *Evaluate options for your building project and establish achievable goals.*
- ✓ *Develop a whole building sustainable design vision.*
- ✓ *Seek green building certification to showcase your efforts.*
- ✓ *Institutionalize sustainable building by:*
  - *Adopting sustainable building policies.*
  - *Incorporating sustainable building principles in standard contract documents.*
  - *Establishing a long-term sustainable building plan.*

Top 20 Cost-Effective Ways to Green an Affordable Housing Project

1. Design water-efficient landscapes.
2. Install water-efficient toilets and fixtures.
3. Use concrete composed of 15 percent or more fly ash.
4. Use paint with low or no volatile organic compounds (VOC).
5. Seal all exposed particleboard to eliminate off-gassing of formaldehyde.
6. Install carbon monoxide detectors.
7. Vent the range hood to the outside.
8. Maximize natural day lighting.
9. Provide overhangs or screens on south-facing windows.
10. Incorporate natural cooling and ventilation.
11. Select light-colored roofing.
12. Use recycled fiberglass or cellulose insulation in walls and ceilings.
13. Install high R-Value insulation.
14. Install fluorescent lights with electronic ballasts.
15. Install compact fluorescent light bulbs.
16. Install lighting controls (for example, occupant sensors or timers).
17. Install Energy Star refrigerators and other appliances.
18. Use engineered wood for headers, joints, and sheathing.
19. Install ceiling fans.
20. Select double-paned, spectrally selective windows.

Source: Adapted from Global Green USA.
www.globalgreen.org/programs/20ways.html

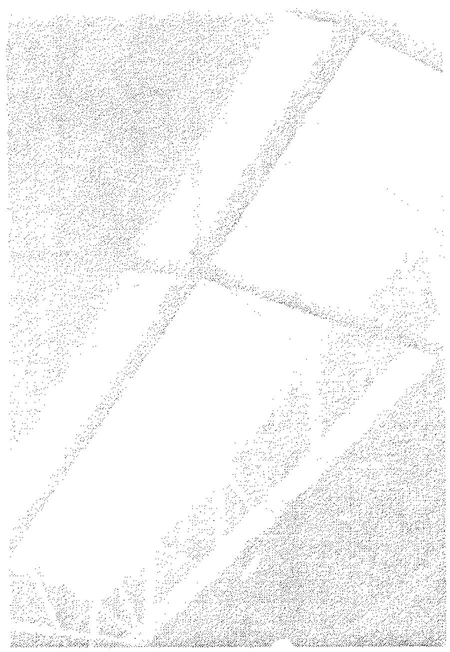
The most effective approach to sustainable building is to adopt a whole-building sustainable design vision from the very beginning (as described below). However, in practice this may not always be possible. Regardless of circumstances, consider, at a minimum, incorporating a few select elements. This list provides 20 examples of cost-effective ways to "green" an affordable housing project. A similar but more specific list could be assembled for any type of building project, large or small.

At a minimum, begin by using a few select green elements.

Plan and work with qualified sustainable building professionals.

Sustainable building is a proven approach that works, as this guide illustrates. One of the most effective ways to implement sustainable practices is to hire professionals who are already highly motivated, experienced, and knowledgeable about sustainable and green building. (See examples at the end of this module.) The number of building professionals knowledgeable and experienced in green building is growing, especially in California. Regardless of the expertise of selected professionals, the Tribe should strive to hire and work with the project architects, contractors, and suppliers from the beginning of any given project to evaluate and select the best sustainable building approaches for the particular situation.

Some building professionals may be skeptical or lack motivation to find affordable, innovative solutions. Requiring that the project building professionals adhere to sustainable building principles is reasonable, although this may require increased activity on the Tribe's part. Adherence to green building principles can be part of any Tribal bid and contract documents for architects, contractors, and/or suppliers.



This guide and its resource suggestions can help project planners, architects, or contractors learn more about specific sustainable building strategies. Directories of green building professionals available online include the U.S. Green Building Council's list of professionals accredited through their *Leadership in Energy and Environmental Design* (LEED) program and their "Sustainable Source Directory of Sustainable Building Professionals." (See Web site listings at the end of this module.)

Evaluate options for your building project and establish achievable goals.

Since every building project is unique and has its own financial, geographic, and function parameters to work with, there are many varied ways to incorporate sustainable aspects into building projects. First and foremost, green building involves use of an integrated approach to design that does its best, under the particular circumstances, to create environmentally sound and resource-efficient buildings. Given this, the best place to start is to work with the building team to evaluate the options and establish clear, achievable goals. Every project's goals will vary, but any set of project goals should consider and reflect the project priorities, building type, location, and budget. There really is no one approach.

Using a three-bedroom home as an example, the chart on the following page illustrates three scenarios (among many possible approaches) for incorporating green building strategies.

- Option one includes many sustainable development approaches and adds slightly more than $1,500 to the $150,000 conventional home price. But, including reduced energy costs, this investment yields a $46 per year net savings to the occupants.
- Option two combines these approaches with select indoor air quality measures, adding $523 in up-front costs for a total of slightly more than $2,000 in added sustainable building costs. Including energy savings, the combined option one and option two investments pay for themselves over time.
- Option three adds a range of "high end" sustainable building measures, perhaps enough to qualify the building for certification under a yet-to-be released LEED certification process for homes. This premier approach adds considerably to the home's cost by more than $10,000, with a net annual cost increase of $856. While this is but one example, it illustrates the many tradeoffs and options available to sustainable building designers. The most important skills may be creativity, innovation, and patience in evaluating different options against your particular needs and budget.

PART 8. RESOURCES

RECOMMENDED GREEN PROGRAMS and PUBLICATIONS

American Solar Energy Society (ASES)
www.ases.org

Green Building Guidelines: Meeting the Demand for Low-Energy, Resource-Efficient Homes.
by he Sustainable Building Industries Council.

NHAB Model Green Home Building Guidelines
by the National Association of Home Builders

The Solar House. 2002. Daniel Chiras. Chelsea Publishing Co., White River, VT.

US Department of Energy, Energy Efficiency & Renewable Energy. www.eere.energy.gov

TRAINING

The US Green Building Council's Leadership in Energy and Environmental Design (LEED) program represents a major step forward for the construction industry - a way of designing and building energy-efficient buildings that have minimal environmental impact.
To learn about LEED certification training, visit their web site at: www.usgbc.org/leed

PRODUCTS

Green Building Products - The GreenSpec® Guide to Residential Building Materials
by BuildingGreen Inc.

GreenSpec® Directory; Product Listings and Guideling Specifications, 6th Edition 2006
by BuildingGreen Inc.

For lists of Arizona suppliers visit: www.azsolarcenter.com.

Sources used in this tool kit:

This Tool Kit compiled by Norman Lowe as part of NAU independent study course from:

Building and Buying Green in Indian Country; A Practical Guide for California Tribes, and follows national guidelines set by the US Green Building Council's (USGBC) Leadership in Energy and Environmental Design's (LEED) *LEED for Homes Program Pilot Rating System.*

Building Green Advisor Version 1.1.2 An interactive green design tool linking design strategies, case studies, and product library. Building Green, Inc. 2002

Housing Initiative Planning and Design Symposium. February 1999. The Navajo Nation Division of Community Development Design and Engineering Services, with US DOE.

Native American Sustainable Communities Project; Balancing Economics, Environment, and Culture. Dec 2000. Great Lakes Environmental Finance Center, Cleveland State University Urban Center, Cleveland, Ohio.

The Sun-inspired House. 2005. Deborah Rucker Coleman. Sun Plans, Inc. Citronelle, Al.

US Green Building Manual. US Green Building Council. www.usgbc.org/publications.

US Department of Energy, Energy Efficiency & Renewable Energy. www.eere.energy.gov